**Technical, Environmental,
and Socioeconomic Factors
Associated with Dry-Cooled
Nuclear Energy Centers**

April 1976

**Prepared for the
Office of Special Studies of the
United States Nuclear Regulatory Commission**

Battelle
Pacific Northwest Laboratories

BNWL-1985

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Nuclear Regulatory Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, nor assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, nor represents that its use would not infringe privately owned rights.

Technical, Environmental,
and Socioeconomic Factors
Associated with Dry-Cooled
Nuclear Energy Centers

April 1976

Prepared for the
Office of Special Studies of the
United States Nuclear Regulatory Commission

Battelle
Pacific Northwest Laboratories
Richland, Washington 99352

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

FOREWORD

In accordance with Section 207 of the Energy Reorganization Act of 1974, the Nuclear Energy Commission evaluated the feasibility of nuclear energy centers, including power-plant centers, fuel-cycle facility centers, and combined power-plant and fuel-cycle facility centers. One of the tasks was the evaluation of the technical, environmental and socioeconomic aspects of dry-cooled nuclear energy centers. Since heat dissipation by dry-cooling requires far less water than any other method used in large power plants, water availability becomes less of a constraint, and power plants can be sited in semi-arid and arid regions.

This report includes a review of the current state-of-the-art of dry-cooling technology for industrial and power-generating facilities and an evaluation of its technical potential and cost for large nuclear power plants. Criteria are then formulated for coarse screening of the arid regions of the Western United States to select a surrogate site for more detailed site-specific analyses. The screening criteria included seismic considerations, existing transportation facilities, institutional and jurisdictional constraints, waste heat dissipation effects, water requirements, and ecologic and socioeconomic considerations.

The Galt site near Las Vegas, Nevada was selected for the surrogate site analysis to assess important issues related to the construction and operation of twelve dry-cooled nuclear power plants at an arid location remote from major load centers. The assessment covers geotechnical, atmospheric and hydrologic considerations, special aspects of transporting large equipment

overland to the site from seaports, analyses of potential transmission routes to major load centers, local institutional and taxing provisions, and ecologic and socioeconomic impacts.

The selection of the Galt site does not imply that a nuclear energy center is planned for this location. The assessment of a surrogate site only serves the purpose of providing realistic data for the identification and analysis of technical, environmental and socioeconomic issues of a potential dry-cooled nuclear energy center at any arid location in the Western United States.

CONTENTS

1.0	INTRODUCTION	1
1.1	THE NUCLEAR ENERGY CENTER SITE SURVEY.	1
1.2	THE ADVANTAGE OF DRY COOLING	1
1.3	FACTORS INTRINSIC TO A DCNEC ANALYSIS.	2
1.4	SCOPE OF THE REPORT.	3
2.0	HEAT DISSIPATION WITH DRY COOLING TOWERS	4
2.1	TYPES OF DRY COOLING SYSTEMS	4
2.1.1	System Alternatives.	5
2.1.2	Heat Transfer Surfaces	5
2.1.3	Arrangement of Tube Bundles.	9
2.1.4	Mechanical Draft Dry Cooling Towers.	9
2.1.5	Natural Draft Dry Cooling Towers	10
2.2	AREAS OF CONCERN TO THE UTILITY INDUSTRY	14
2.2.1	Costs.	14
2.2.2	Turbine Development.	19
2.2.3	Experience and Reliability	21
2.2.4	Possible Operational Problems.	23
2.3	DESIGN CHARACTERISTICS	27
2.3.1	Sizing Dry Cooling Systems for Minimum Cost	27
2.3.2	Size of Dry Cooling Systems.	27
2.3.3	Impact of Reactor Type or Dry Cooling Systems.	28
2.3.4	Spacing of Cooling Towers and Land Area Requirements.	31
2.3.5	Plant Efficiency Versus Ambient Air Temperatures	32
2.3.6	Outlet Air Flow and Temperatures	32
2.4	OPERATIONAL EXPERIENCE	34
2.5	PROSPECTS FOR IMPROVING DRY COOLING SYSTEMS.	36
2.5.1	Costs.	36

2.5.2	Advanced Concepts Under Development.	38
2.6	DCNEC REPORT ASSUMPTIONS	45
REFERENCES - SECTION 2.		46
3.0	SURROGATE SITE SELECTION PROCESS	48
4.0	CONSIDERATIONS IN THE SITE SELECTION	49
4.1	SUMMARY OF COARSE SCREENING.	49
4.2	TRANSPORTATION NEEDS	51
4.2.1	Shipment of Major Power Plant Components . . .	51
4.2.2	Region Evaluations	54
4.3	TRANSMISSION	57
4.3.1	Summary.	57
4.3.2	Projected Loads.	58
4.3.3	Existing Systems	59
4.3.4	DCNEC Switching Station.	62
4.3.5	Technical Assumptions and Bases.	62
4.4	INSTITUTIONAL CONSTRAINTS.	67
4.4.1	Siting Constraints Imposed by State Regulations.	67
4.4.2	Dedicated Land Use	72
4.5	SEISMICITY	77
4.5.1	Seismic Risk	77
4.5.2	Seismic Suitability.	79
4.5.3	Selection Conclusions.	79
4.6	WATER RESOURCES.	81
4.6.1	Water Requirements	81
4.6.2	Water Supply Assessment in Surrogate Regions.	81
4.7	ATMOSPHERIC EFFECTS.	85
4.7.1	Air and Land Requirements.	86
4.7.2	Wind Generation.	87
4.7.3	Plume Rise	89
4.7.4	Plume Temperature Diffusion.	92

4.7.5	Potential Impacts.	98
4.7.6	Summary of Atmospheric Effects	100
4.7.7	Climatology of the Surrogate Regions	101
4.8	ECOSYSTEMS	108
4.8.1	DCNEC Impacts on Existing Ecosystems	108
4.8.2	Rare or Endangered Species	111
4.8.3	Existing Ecosystems in the Surrogate Regions.	113
4.9	SOCIOECONOMIC IMPACTS.	116
4.9.1	Construction and Operating Work Force Size and Timing.	116
4.9.2	Secondary Employment	118
4.9.3	Population	122
4.9.4	Private Business	123
4.9.5	Housing.	123
4.9.6	Public Services and Facilities	124
4.9.7	Taxes.	126
4.9.8	Population Density and Distribution.	128
4.10	SITE SELECTION CONCLUSIONS.	130
4.10.1	Basis For Region 2 Selection.	130
4.10.2	Basis for Galt Surrogate Site Selection	131
	REFERENCES - Section 4.	135
5.0	PRELIMINARY ANALYSIS OF THE SURROGATE SITE	138
5.1	SITE DESCRIPTION	138
5.1.1	Location	138
5.1.2	Natural Features	138
5.1.3	Human Activity	140
5.2	TRANSPORTATION	141
5.2.1	Major Components	141
5.2.2	Labor Force.	144
5.2.3	Equipment and Materials.	146
5.3	TRANSMISSION	147
5.3.1	Load Center Servicing.	147
5.3.2	Transmission Line Network.	148

5.3.3	Availability of Right-of-Way	150
5.3.4	Economic Summary	153
5.3.5	Summary.	155
5.3.6	Recommended Future Work.	156
5.4	LAND USE CONSIDERATIONS.	157
5.4.1	Nevada State Policy.	157
5.4.2	Conflicting Land Use	158
5.5	GEOTECHNICAL CHARACTERISTICS	167
5.5.1	Structural Aspects	167
5.5.2	Seismic Characteristics.	170
5.5.3	Soil Foundation Characteristics and Stability.	174
5.5.4	Volcanic Effects	177
5.5.5	Mineral Resources.	177
5.6	HYDROLOGIC CONSIDERATIONS.	179
5.6.1	Summary of Surrogate Site Hydrology Relevant to a DCNEC.	179
5.6.2	Water Supply	180
5.6.3	Water Use.	186
5.6.4	Water Quality.	189
5.6.5	Conclusions.	192
5.7	CLIMATOLOGY.	193
5.7.1	Temperature.	193
5.7.2	Precipitation.	197
5.7.3	Wind	197
5.8	ECOSYSTEMS	200
5.8.1	Description.	200
5.8.2	Impacts.	220
5.9	SOCIOECONOMIC IMPACTS.	225
5.9.1	Population Size and Distribution	225
5.9.2	Labor Force.	226
5.9.3	Income	228
5.9.4	Private Business	228
5.9.5	Community Services and Facilities.	229

5.9.6	Government Revenues.	231
5.9.7	County Land Use Breakdown.	233
5.9.8	Socioeconomic Impacts of a DCNEC at the Surrogate Site	233
5.10	OTHER ENVIRONMENTAL CONSIDERATIONS.	238
5.10.1	Aesthetics.	238
5.10.2	Noise	239
REFERENCES - Section 5.		240
APPENDIX A.		A-1
A.1	LOAD GROWTH PROJECTIONS.	A-1
A.1.1	BNW Forecast	A-1
A.1.2	Utility Forecast	A-5
A.1.3	Tyrrell Forecast	A-6
REFERENCES - APPENDIX A		A-8
A.2	COMPARISON OF TRANSMISSION ASPECTS IN DISPERSED SITING.	A-9
A.3	TRANSMISSION ASPECTS OF A 3-DCNEC CONFIGURATION SERVING CALIFORNIA LOAD CENTERS	A-14
A.3.1	Cost Estimates - 3-DCNEC Configuration	A-15

FIGURES

2.1	Diagrams of Wet and Dry Forced-Air Cooling Towers.	4
2.2	Direct, Dry-Type Cooling Tower Condensing System With Mechanical Draft Tower.	6
2.3	Indirect, Dry-Type Cooling Tower Condensing System With Induced-Draft Tower	7
2.4	Indirect, Dry-Type Cooling Tower With Surface Condensing System	8
2.5	200 MWe Station With Direct Air-Cooled Condensation - Utrillas, Spain.	11
2.6	Natural Draft Cooling Tower at the 150 MWe Plant - Ibzenburen, Germany	12
2.7	Area Required for Dry Cooling Modules	29
2.8	Power Requirements for Fans and Water Pumps	30
2.9	Approximate Normalized Plant Output as a Function of Ambient Air Temperature (Based on ITD of 70°F @ 70°F	33
4.1	Surrogate Regions Selected for Potential DCNEC Suitability Analysis.	50
4.2	Major Transmission Lines - 1985 kV Accented	61
4.4	Conceptual DCNEC Plan Typical Spacing of Transmission Switching Stations	63
4.5	Representative Switching Arrangement DCNEC Transmission Line Terminals	64
4.6	Oregon Suitability Classifications for Nuclear Power Plant Siting.	68
4.7	Irrigable Land, Region 1.	70
4.8	Dedicated Use Areas, Region 1	73
4.9	Dedicated Use Areas, Region 2	74
4.10	Dedicated Use Areas, Region 3	75
4.11	Dedicated Use Areas, Region 4	76
4.12	Seismic Risk Map of the United States (Modified from Algermissen, 1969)	78

FIGURES (continued)

4.13	Seismic Suitability in the DCNEC Study Region.	80
4.14	Major Ground-water Aquifers	84
4.15	Comparison of Combined and Single Plume Rise.	91
4.16	Plume Rise Enhancement for a Four Reactor Cluster	93
4.17	Plume Rise Enhancement for a Three-Cluster Dry Cooled Nuclear Energy Center.	94
4.18	Dissipation of Temperature Excess for Single Dry Cooling Systems, Four Power Plant Clusters, and a Three Cluster Center With Distance.	96
4.19	Dissipation of Temperature Excess With Distance for a 12 Unit DCNEC.	97
4.20	Number of Hours With Dry-bulb Temperature Exceeding a Given Value at Each Surrogate Site.	107
4.21	Construction and Operating Work Force for 6 Months, 1-Year and 2-Year Reactor Completion Intervals.	120
4.22	Population Centers.	129
4.23	Potential Surrogate Sites for Analysis of a Dry-Cooled Nuclear Energy Center	132
4.24	Location of Surrogate Site for DCNEC Analysis.	134
5.1	Topography of the Galt DCNEC Surrogate Site.	139
5.2	Steam Generator Shipment Route From Long Beach Harbor to Site	142
5.3	Conceptual Transmission System for DCNEC at Galt Surrogate Site 500 kV AC Lines.	149
5.4	Land Ownership of Galt Site	160
5.5	Federal Military Reserves	161

FIGURES (continued)

5.6	National Forests	163
5.7	National Preservation Areas	164
5.8	Indian Reservations	165
5.9	Surrogate Site Area and Mapped Faults	168
5.10	Meadow Valley Wash Drainage Basin	181
5.11	Hydrogeologic Features of the Galt Site	183
5.12	Number of Hours/Year With Dry-Bulb Temperature Exceeding a Given Value at the Galt Site.	196
5.13	Seasonal Correlation of Average Wind Speed and Temperature	198
5.14	Diurnal Correlation of Wind Speed and Temperature	199
5.15	Diagrammatic Representation of Vegetation Zonation in a Closed Valley System in Southern Nevada	202
A.1	FPC Power Supply Areas (PSAs) in the United States	A-2
A.2	Regional Electric Reliability Councils in the United States.	A-3
A.3	Sites and Site Areas Under Investigation for Post-1985 Nuclear Plants in Southern California and Arizona, in Relation to Location of Load Centers.	A-10
A.4	3-DCNEC Complex-Configuration A	A-16
A.5	3-DCNEC Complex-Configuration B	A-17
A.6	3-DCNEC Complex-Configuration C	A-18

TABLES

2.1	Current Estimates of Average Costs of Power From New 1100 MWe Base Load Plants With Evaporative Cooling, 1975 Dollars.	17
2.2	Range of Values for Major Plume Parameters From Dry Cooling Towers	33
4.1	Size of Largest Light Water Reactor Components. . .	51
4.2	Estimated New Capacity Requirements, Including Reserves.	58
4.3	Water Requirements for Nuclear Power Plants	82
4.4	Airflow Model Parameters.	88
4.5	Radial Velocities Required to Give the Needed Airflow for Dry-Cooling Systems (MPH)	88
4.6	Momentum Rise for a Dry Cooling Tower Plume (in Feet)	89
4.7	Buoyant Rise for a Dry Cooling Tower Plume (in Feet)	90
4.8	Representative Climatology of Region 1, Southeastern Oregon	102
4.9	Representative Climatoloty of Region 2, Eastern Nevada.	103
4.10	Representative Climatology of Region 3, California-Arizona Border	104
4.11	Representative Climatology of Region 4, Sacramento Valley	105
4.12	Rare or Endangered Species in the Areas Considered for DCNEC Siting	112
4.13	Potential Construction Force for Dry-Cooled Nuclear Energy Centers.	117
4.14	Projected Operating Work Force and Total Work Force for a Dry-Cooled Nuclear Energy Center	119
5.1	Load Growth To Be Supplied By DCNEC	148
5.2	Earthquake History and Source Near DCNEC Site	171

TABLES (continued)

5.3	Modified Mercalli Intensity Scale	175
5.4	Estimated Average Annual Precipitation and Ground-Water Recharge in the Meadow Valley Area	184
5.5	Annual Discharge of Muddy River (acre-feet)	187
5.6	Ground Water Stored in Valleys Surrounding the Surrogate Site.	189
5.7	Criteria for Salinity Hazard Classification By U.S. Department of Agriculture	190
5.8	Chemical Analyses of Water From the Meadow Valley Area	191
5.9	Las Vegas Climatology	194
5.10	Common Plants of a Creosote Bush Community in Southern Nevada and Percent of Ground Cover.	204
5.11	List of the Mammals of the Desert National Wildlife Range.	206
5.12	Birds of the Desert National Wildlife Range	211
5.13	Amphibians and Reptiles of the Desert National Wildlife Range	215
5.14	Distribution of Family Income in Clark and Lincoln Counties.	228
A.1	Expected 1985-2000 Capacity Additions Assuming 1956-1971 Trend Continuation	A-4
A.2	Current Electric Utility Estimates of New Capacity, Including Reserves.	A-5
A.3	Expected 1985-2000 Capacity Additions According to Tyrrell's Forecasts.	A-7

ACKNOWLEDGMENTS

The work performed in this study was part of the 1975 Nuclear Energy Center Special Studies sponsored by the U.S. Nuclear Regulatory Commission. Valuable guidance was provided by Messrs. M. L. Ernst, D. E. Sells, R. T. Jaske and M. L. Au of the Regulatory Commission staff.

Much of the basic information for the surrogate site selection and analysis was obtained through personal contacts of the team members with various state and federal agencies in the western states. In addition, much valuable information was contributed by both public and private electric utilities in the southwestern states.

This report was prepared under the project direction of Mr. Walter W. Laity, senior research engineer, and Dr. Albin Brandstetter, research associate, in the Water and Land Resources Department of Battelle-Northwest. Mr. Laity directed the generic assessment and the site screening and Dr. Brandstetter directed the preliminary assessment of the surrogate site. Mr. Steven J. Shupe contributed significantly to the organization and writing of the final report.

Principal contributors were R. L. Watts and B. M. Johnson - dry cooling concepts; R. L. Richardson, C. C. Diamond (consultant) and W. J. Dowis (consultant) - electrical transmission analysis; W. H. Swift and S. J. Shupe - transportation; J. G. Droppo and J. V. Ramsdell - atmospheric effects and climatology; R. W. Wallace - geology and seismology; M. H. Karr and S. J. Shupe - hydrology, water and land resources; W. T. Hinds and R. E. Fitzner - ecological considerations; L. E. Erickson and K. A. McGinnis - socioeconomic analyses, load forecasts and cost analyses; and M. H. Karr, S. J. Shupe and A. H. Schilling - institutional constraints.

1.0 INTRODUCTION

1.1 THE NUCLEAR ENERGY CENTER SITE SURVEY

In accordance with Section 207 of the Energy Reorganization Act of 1974, the Nuclear Regulatory Commission is performing a Nuclear Energy Center Site Survey (NECSS) to identify land areas potentially suitable for nuclear energy centers. The purpose of this effort is to provide criteria for assessing the feasibility and practicality of locating several nuclear power reactors and related facilities at a single location. Site selection is not aimed at determining preferred locations for constructing large power generating facilities. Particular surrogate sites are specified merely to provide realistic data for evaluating the nuclear energy center concept.

1.2 THE ADVANTAGE OF DRY COOLING

One aspect of the NECSS is a surrogate site analysis of the technical, environmental, and socioeconomic factors associated with construction and operation of a dry-cooled nuclear energy center (DCNEC). Dry-cooled centers were included as part of the NECSS primarily because they allow increased flexibility in siting. Since heat dissipation by dry cooling requires far less water than any other method used in large power plants, water availability becomes much less of a constraint in DCNEC siting. Consideration can be extended to semi-arid and even arid areas. Furthermore, as demands on existing water resources increase, dry cooling is likely to receive attention even in areas not currently short of water.

1.3 FACTORS INTRINSIC TO A DCNEC ANALYSIS

Historically, the availability of water has influenced the extent of development in an area. Thus, the arid regions considered in the DCNEC analysis characteristically have sparse populations, low levels of industrial activity, and limited transportation facilities. As a result, additional constraints become involved that are generally absent in a wet-cooled NEC surrogate site where the availability of water has encouraged previous development.

For example, the transmission analysis is complicated because electricity load centers potentially served by a DCNEC would be scattered over a large area. Technical, economic and environmental aspects of electrical transmission are among the more critical issues for siting nuclear energy centers. Various technical and engineering obstacles have to be solved to transmit from 12 to 48 gigawatts of power, the economic penalties associated with transmitting the power from remote sites to load centers may have significant effects on site selection and the cost of power to the consumer, the availability of land and environmental considerations are important constraints for transmission route selection, and questions of electric reliability associated with the potential interruption of the power supply need to be addressed.

Transportation considerations become more complex when large equipment traditionally shipped by water has to be transported overland and where the rail and highway network is dispersed. In addition, various impacts resulting from construction and operation of a nuclear energy center differ between remote and

developed regions. Locating several thousand workers and supporting facilities in an isolated area creates unique environmental and socioeconomic problems.

A DCNEC surrogate site analysis is further complicated by a limited information base. Detailed data on the isolated regions under study are generally lacking. Site-specific work, such as geologic, hydrologic and ecologic studies, must be undertaken to fill the gaps.

As a final factor, dry cooling systems are considerably different from evaporative cooling and once-through cooling systems. Unique effects on plant operation and perhaps unique impacts on the environment are associated with the heat dissipation system of a DCNEC. However, since the use of dry cooling at large power plants is rare, the extent to which these effects may pose problems has yet to be determined.

1.4 ORGANIZATION OF THE REPORT

The report is organized into three major areas: a description of dry-cooling technology, the surrogate site selection process, and the assessment of the surrogate site for a DCNEC.

The state-of-the art of dry-cooling technology for industrial and power purposes is reviewed in Section 2.0, considerations in the site selection are presented in Sections 3 and 4, and a preliminary assessment of the Galt, Nevada surrogate site is given in Section 5. Various electric load growth projections and comparisons of transmission aspects for various nuclear power siting arrangements are included in the Appendix.

2.0 HEAT DISSIPATION WITH DRY COOLING TOWERS

Before venturing into the DCNEC surrogate site selection process and analysis, it is useful to understand the basic concepts of the dry cooling method of heat dissipation. This section provides such a background.

2.1 TYPES OF DRY COOLING SYSTEMS

In this section, the terms "dry cooling" and "dry cooling tower" are used to denote the power plant heat rejection system or structure in which the rejected heat is transferred directly to atmospheric air across a solid interface without the evaporation of water. Although this terminology is somewhat confusing, it has come into common use in the power industry as the antithesis of the term "wet cooling tower" and serves to contrast the basic difference between the two heat rejection concepts. Figure 2.1 is a schematic diagram of the two different approaches to heat rejection.

Figure 2.1 Diagrams of Wet and Dry Forced-Air Cooling Towers

2.1.1 System Alternatives

Three general approaches to air-cooled dry heat rejection (shown as Figures 2.2-2.4, respectively) have been considered: (1) condensation of the turbine exhaust in an air-cooled condenser; (2) direct contact condensation of the turbine exhaust steam by water, followed by air cooling of the recirculated water; and (3) surface condensation in conventional water-to-steam condenser equipment, followed by air cooling of the recirculated water. The advantage of the first approach is that the equipment operates over the largest possible temperature driving force; however, provision must be made for handling a very large vapor volume. The second process has a fairly compact condenser and an air heat exchanger operating at near atmospheric pressure on the fluid side. However, the temperature driving force is less than in the case of the air-cooled condenser because of the cooling of the hot fluid as it moves through the condenser, and consequently a larger heat exchanger is required. The third approach may be required for nuclear plants equipped with boiling-water reactors (BWR) to provide the necessary isolation of the turbine steam which recycles through the reactor as the coolant and therefore must be contained within the reliable closed loop.

2.1.2 Heat Transfer Surfaces

The heat transfer tubes used in presently available dry cooling equipment are the extended-surface type with circumferential fins on the air side (outside). The pressure-containing tubular section may be either circular or elliptical in cross section and constructed of either carbon steel or aluminum. The fins may be attached in a number of ways: either L-shaped and spirally wound around the tubes, extruded from an outside

Figure 2.2 Direct, Dry-Type Cooling Tower Condensing System With Mechanical Draft Tower

Figure 2.3 Indirect, Dry-Type Cooling Tower Condensing System With Induced-Draft Tower

Figure 2.4 Indirect, Dry-Type Cooling Tower
With Surface Condensing System

aluminum tube which is slipped over an inner carbon steel tube and compressed onto the tube as a part of the finning operation to form an effective mechanical contact between the two, or formed of separate metal sheets which are mechanically bonded to the tube by hot dip galvanizing which also forms a protective corrosion-resistant coating. Most tube designs employ a ratio of outside-to-inside surface ranging from 15 to 20. Preferred tube sizes for both indirect condensing system heat exchangers and direct condensing system air-cooled condensers range from about 7/8 inch to 1-1/2 inch OD.

2.1.3 Arrangement of Tube Bundles

Generally, tube bundles are arranged in banks, 2 to 5 rows deep. The tubes are parallel and spaced at a pitch slightly greater than their outside diameter. They may be arranged in an in-line pattern or in a staggered pattern. The tubes are usually secured in a carbon steel box header with screwed plugs opposite each tube end as a means for tube installation, reaming, or replacement. Alternatively, bolted coverplates may be used. The assembled tube bundles are arranged in a number of ways. Essentially, they may be classed as "V" shaped with inclined tubes, "V" shaped with substantially horizontal tubes, "A" shaped with inclined tubes, "A" shaped with substantially horizontal tubes, vertical tube bundles with either horizontal or vertical tubes, and flat or horizontal bundles with substantially horizontal tubes.

2.1.4 Mechanical Draft Dry Cooling Towers

Motor-driven propeller fans provide cooling air flow for mechanical draft dry air cooling heat transfer equipment. These fans vary in size from about 16 feet to 35 feet in diameter. Consideration has been given to fans as large as 60 feet

in diameter, although none have been installed to date in other than test stands. Figure 2.5 shows a typical installation at a 200 MWe station in Utrillas, Spain.

Air flow is controlled by either of two methods: variable fan speeds, usually in steps of 0, 1/2, and full speed; or variable-pitch, constant-speed fans. Variable pitch may range from full reverse to full forward.

The arrangement of tube bundles is related to the type of air circulation provided, forced draft or induced draft. With mechanical draft equipment, the "V" shaped and vertical bundle arrangements are usually provided with induced draft systems. The "A" shaped bundle arrangements are usually used with forced draft systems while the flat or horizontal tube bundle geometries are suitable for either.

2.1.5 Natural Draft Dry Cooling Towers

Cooling air flow for natural draft towers is induced flow and can only be controlled by the use of louvers or dampers. The rate of flow with natural draft towers increases as ambient air temperature decreases. Use of natural draft towers in a climate where freezing temperatures are experienced requires air flow control by louvers or dampers.

Because of the geometry of large natural draft cooling towers, and since the air flow is of the induced-draft type, considerable flexibility is possible in the selection of tube bundle design. One of the early large natural draft dry cooling systems (Figure 2.6) used bundles with tubes in a vertical position, arranged around the tower base. The use of "A" or "V" bundles arranged as a deck within the tower itself has space advantages and contributes to air flow

Figure 2.5. 200 MWe Station With Direct Air-Cooled Condensation - Utrillas, Spain

Figure 2.6. Natural Draft Cooling Tower at the 150 MWe Plant - Ibzenburen, Germany

stability. Flat horizontal bundles are not ordinarily used because of greater space requirements.

There are only three major natural draft dry cooling systems installed outside the Eastern block countries. Two are arranged with vertical tube bundles; the other, recently put into service, uses the "A" shaped tube bundle arrangement. All of these systems are of the indirect condensing type. The "A" shaped tube bundle arrangement mounted inside the tower was used in the most recent natural draft dry cooling tower installation.

2.2 AREAS OF CONCERN TO THE UTILITY INDUSTRY

2.2.1 Costs of Dry Cooling Towers

As one might expect, projected high capital and operating costs are the most important factors currently limiting the use of dry cooling towers. (Ref. 1-5) One or more of the utilities contacted in a recent survey mentioned the studies reported in References 1-5 as the source of the evidence upon which this conclusion was based. In these studies, plant sizes, economic bases, system types and plant locations varied from case to case, so predicted costs of dry cooling cannot be directly compared. However, the results of these studies give some idea of the approximate costs of using dry cooling as opposed to more conventional cooling methods.

In the WEST Associates report prepared by Bechtel, estimates of cost were made for a two-unit coal fired plant located in southcentral Utah at the site of the Kanab coal field. Four types of heat rejection systems were considered: wet cooling towers, a cooling pond, mechanical draft and natural draft dry cooling towers. Dry cooling was found to have the highest power generation costs; cost differentials of 0.9 and 0.91 mill/kW-hr were associated with the mechanical and natural draft towers, respectively, over wet cooling towers (1971 costs). The corresponding additional cost of the cooling pond option was found to be 0.65 mill/kW-hr. In a similar study for Montana Power Company, Bechtel estimated the additional cost associated with the use of dry instead of wet towers for the coal-fired 800 MW Colstrip units 3 and 4 which will be constructed in eastern Montana. It was concluded that dry cooling would cost \$8.5 to \$11.9 million more per year in operating costs (1979 costs). This amounts to a cost differential of approximately 0.9 to 1.2 mill/kW-hr using the same plant factors as in the WEST study.

The Westinghouse, Beck, and McFeran studies examined the additional cost of using dry cooling for nuclear power stations. Westinghouse studied a 1100 MW nuclear plant in the Philadelphia area which would be built in 1978. It concluded that the additional cost associated with the use of dry cooling over wet cooling towers would be 1.4 mill/kW-hr (1978 costs). In the Beck study 860-928 MW plants were examined in locations in the Northeast, Southeast and Western United States. In general, the additional costs associated with dry cooling were found to be approximately 0.9 mill/kW-hr for all locations. This represents a 12% increase in energy costs over evaporative cooling. The McFeran study considered a 1200 MW plant in Western Washington. The additional costs associated with dry cooling were found to be about 0.7 to 0.8 mill/kW-hr more than wet cooling towers.

A dry-cooled plant has higher generating costs than a plant with a wet cooling tower system for several reasons. Capital costs are much greater because of the large and costly dry cooling tower and associated systems. For example, in the Bechtel Colstrip study, the additional total capital cost was estimated to be either \$25,668,000 or \$24,938,000, depending on the type of steam turbine employed. Secondly, a dry-cooled power station will in most cases be somewhat less efficient than a similar wet-cooled plant operating at high dry-bulb temperatures because of the higher heat rejection temperatures. Therefore, fuel costs will also be somewhat higher. At very low dry-bulb temperatures, a dry-cooled plant may not show an enhanced efficiency because of choking in the turbine at very low condenser pressures. Thirdly, a dry-cooled power station cannot generally produce full rated output on a hot day. This means that the loss of energy production must be compensated for by the installation of excess capacity in the unit or the utility system or by purchase or exchange of energy with intertied utilities if a constant load is assumed. The

additional costs associated with this loss of output can be considerable. For example, again for the Bechtel Colstrip study, these additional costs were between \$5,024,000 and \$8,222,000 per year and constituted from 60 to 70% of the total additional costs associated with dry cooling.

These costs of dry cooling, however, may be more than offset by compensating decreases in other cost factors, such as fuel transportation or water. This is apparently the situation which makes the Neil Simpson Station Unit Number 5, a dry-cooled mine mouth plant located at Wyodak, Wyoming, very attractive. The Wyodak site is characterized by its plentiful fuel supplies but almost total lack of cooling water. The costs of the Number 5 unit were compared (Ref. 6) with those of the Ben French Unit Number 1, a similar wet-cooled plant located at Rapid City, South Dakota, which uses coal transported from the Wyodak site. It was found that the average cost of electricity from the Neil Simpson Number 5 unit was 79% of that from the Ben French Number 1 unit. In this case, the absence of fuel transportation costs and water costs more than compensated for the higher costs of the air cooled unit.

All the utilities contacted realize that, as expanding population, agriculture, and industry cause increasing demand for water, its price will increase. This may eventually give the advantage to dry systems. The timing of this occurrence will vary from region to region, but it could take place in some locations as early as 1985.

The process of determining the cost of power from an electric plant has been discussed in the literature. (Ref. 7,8,9) From these sources a general expression for the average costs of power from a new electric plant can be written as follows:

$$AC = \frac{10^2 K_1 a}{8760C} + \frac{K_2 H_r}{10^6} + 0 \quad (1)$$

where:

- AC = average costs ($\text{\$/kW-hr}$)
- K_1 = capital costs ($\text{\$/kW}$)
- a = annual fixed-charge rate (1/yr)
- K_2 = fuel costs ($\text{\$/10}^6 \text{ Btu}$)
- H_r = average heat rate (Btu/kW-hr)
- C = average capacity factor (actual kW-hr/potential kW-hr capacity)
- 0 = operation and maintenance cost ($\text{\$/kW-hr}$)

Current estimates for the parameters in Equation 1 are given in Table 2.1.

TABLE 2.1
CURRENT ESTIMATES OF AVERAGE COSTS OF
POWER FROM NEW 1100 MWe BASE LOAD PLANTS
WITH EVAPORATIVE COOLING, 1975 DOLLARS*

	Light Water Reactor	Coal With SO_x Abatement
Capital Cost (K_1)	\$500/kW	\$400/kW
Capacity Factor (C)	0.65	0.65
Fixed Charge Rate (a)	0.174	0.174
Fuel Cost (K_2)	43¢/10 ⁶ Btu	81¢/10 ⁶ Btu
Heat Rate (H_r)	10,300 Btu/kW-hr	9,500 Btu/kW-hr
Operation & Maintenance (0)	0.1¢/kW-hr	0.216¢/kW-hr
Average Cost (AC)	2.07¢/kW-hr	2.27¢/kW-hr

*From Ref. 9

Some adjustments in the figures given in Table 2.1 are necessary to incorporate the costs of dry cooling as opposed to evaporative cooling. First, the capital costs of evaporative cooling, which amount to about 1% of total capital costs, must be deducted. (Ref. 9) Secondly, the capital costs of dry

cooling must be added. Estimates of these costs currently range from \$30/kW to \$60/kW; \$45/kW will be used here. (Ref. 1,4,10,11) This brings capital costs to \$540/kW for a 1100 MWe LWR. The average cost of power from a new 1100 MWe LWR is then 2.19¢/kW-hr as compared to 2.33¢/kW-hr for a new 1100 MWe coal plant with SO_x abatement.

When hot weather makes the dry cooling towers so inefficient that rated output is not available, then additional capacity, fuel, and possibly maintenance costs must be incurred if this loss in output is to be recouped. It is currently estimated that these costs or "penalties" may add about 20% to the cost of power at the DCNEC bus bar. (Ref. 1) However, the addition of these "penalties" is necessary or correct only if these losses in potential output must be recouped. In this case calculation of the average costs of power (using a capacity factor defined as the ratio of actual output to potential plant capacity) incorporates all the relevant "penalties" automatically: during hot weather the potential capacity is lower and the lower resulting capacity factor increases the average costs of power. Also, the higher backpressure during hot weather increases the heat rate, which increases fuel use and the average cost of power. Furthermore, marginal cost or peak load pricing of electricity may cause the quantity of electricity demanded during hot periods to be less than potential capacity anyway at some points over even a base plant's life cycle. To determine the average cost of obtaining a constant base load through a wet cooled plant and the same constant base load through a dry cooled plant of the same size, additional costs for capacity, fuel, and possibly maintenance must be added to the dry cooled alternative. On the other hand, such "penalties" need not be considered in computing the average cost of electricity from a dry cooled plant of a specified size. Therefore, the average cost of power from a 1100 MWe LWR with dry cooling is 2.19¢/kW-hr, while the average cost of 1100 MWe of power produced on a constant year-round basis from LWRs with dry cooling is about 2.63¢/kW-hr.

It currently appears that a 12-reactor DCNEC would realize few economies of scale over dispersed sites. Previous work on clusters of 4 and 20 reactors indicates that 5-10% savings in the average cost of power may be expected from a 12-reactor center over dispersed sites. (Ref. 12) This includes transmission cost differences, which offset savings in construction costs for the 20-reactor nuclear center. Assuming 7% savings for a 12-reactor DCNEC brings the average cost of power at the DCNEC bus bar to 2.28¢/kW-hr or 2.44¢/kW-hr for a constant 12 times 1200 MWe output. Adding transmission costs of 0.4¢/kW-hr estimated in Section 5.3 of this report yields an average cost of power produced at the DCNEC of about 2.68¢/kW-hr at the local substation, or 2.84¢/kW-hr for a constant 14,400 MWe output.

2.2.2 Turbine Development

A second problem for both utilities and A&E firms is the unavailability of large turbines that are suitable for use in dry cooled power stations.

Turbines for conventionally-cooled plants are designed to operate at back pressures ranging from less than 1.0 to 4.0 in. Hg abs with maximum design back pressure of about 5.5 in. Hg. For plants using dry cooling towers, the back pressure would necessarily reach 12 to 15 in. Hg during summer temperatures near 100 F. During cold winter months, back pressures as low as 1.0 in. Hg could be experienced. Large steam turbines of conventional design cannot meet these severe performance requirements.

General Electric Company has developed sufficient information to furnish quotations (Ref. 13) for large steam turbines with back pressures up to 15 in. Hg for fossil fueled plants, and

they are providing the 330 MWe unit for the Wyodak plant. However, some questions remain regarding the predicted performance and reliability of this turbine under certain operational conditions associated with dry cooling. Westinghouse apparently is not prepared to quote prices and delivery on high back pressure turbines at this time.

The problems of designing a turbine for the high back pressures associated with a dry-cooled plant include the following:

- The design must accommodate the high differential expansion between the turbine rotor and casing.
- Additional heating of the exhaust hoods and foundation will occur and must be considered in the design.
- Blade vibration may occur.
- Aerodynamic heating of the turbine blades may occur at off-design conditions.
- High bending stresses will occur on the blades due to high back-end loading.
- Fluttering and buffeting of the blades may occur during certain circumstances.
- There is a greater potential for overspeed during sudden load changes, which must be prevented by special controls.
- Large changes in the operating temperatures of the last stage blading can occur as a result of sudden load changes.

High back pressure turbines should be nearly as efficient as low back pressure units. However, a reduction in overall plant efficiency will come as a result of the higher effective heat rejection temperatures--not with any significant increase in the thermodynamic irreversibility of the turbine itself.

It was generally indicated that the problems associated with high back pressure turbines listed above are not insurmountable

and could be engineered around. However, this would require a research and development investment which can be justified only if a market for these turbines develops. At present, the potential size of this market and its rate of development are uncertain.

2.2.3 Experience and Reliability

A major concern of most of the utilities and A&E firms contacted was uncertainty about the reliability and lifetime of dry cooling towers and associated equipment. The relatively short operating experience with large dry cooling towers does not provide a solid basis on which to project component lifetime and reliability over the projected 35 to 50 year lifetime of a power generation station.

Although dry cooling towers have been in service in the petrochemical industry for a considerable period of time, long service life was not generally a primary design criteria. Therefore, these units do not provide the experience required to assure the durability of existing designs and materials.

In the Colstrip study performed by Bechtel, the lifetime was "realistically" estimated as 15 years based on the "opinion of heat exchanger manufacturers." This would mean that the dry cooling tower heat exchangers would have to be changed at least once during the lifetime of the plant. On the other hand, one dry cooling tower vendor claimed that there is no reason to expect that his galvanized steel heat exchangers will not last for the full life of the plant, based on petrochemical industry experience. However, with the projected accelerated use of aluminum fin tube designs, lifetime becomes more uncertain, especially in areas of atmospheric contamination. Additional lifetime concerns were expressed regarding hybrid cooling tower concepts, especially units that use treated sewage for makeup.

In such units, backslash or water contaminants recirculated through the atmosphere could have a deleterious effect on life-time due to air side corrosion and solids deposition.

About two dozen dry cooled power stations have been built or are under construction in Europe, Africa and Asia. (Ref. 8) In these locations, electrical utilities do not experience summer peak demands as in the United States. Therefore, the energy and capacity penalties associated with high ambient temperature operation are not as important. The resulting more favorable economics has led to the widespread use of dry cooling in these locations. The utilities and A&E firms generally recognize that much valuable operational and reliability information is being obtained in these foreign installations. However, many express the concern that the generally small average size of these plants and their relatively recent construction (the oldest plant began operation in about 1960) does not provide a solid technological basis to permit design scaleup to 800 to 1200 MWe plants with 35+ year lifetime.

Most utilities questioned took a very conservative approach to scaleup (extrapolation) of power plant technology. Most stated that they would prefer to observe the operation of a dry-cooled plant for a period of time before they would feel comfortable building a similar plant. The range of allowable plant capacity scaleup factors mentioned by the utilities ranged from 110 to 150%. The construction of the 330 MW Wyodak plant by PP&L and Black Hills Power and Light from experience gained from the 20 MW Neil Simpson Number 5 unit was considered a very bold extrapolation by other utilities. However, the supplier of the Wyodak air-cooled direct condensing system believes that if this installation proves successful, a direct extrapolation to 800 MWe (or even 1200 MWe) can be confidently made.

2.2.4 Possible Operational Problems

The utilities, A&E's and vendors expressed concern over a number of various operational problems associated with dry-cooled power plants. The most frequently mentioned included freezeup, water treatment, dependence on weather conditions, and long-term degradation of heat transfer performance.

2.2.4.1 Freezeup Problems

Freezeup of the dry cooling tower heat exchangers during cold weather is a major problem in direct condensing and Heller system (contact condenser) dry cooling towers where no anti-freeze substance may be used. The large exposed heat transfer surfaces are susceptible to rapid cooling during plant load fluctuations and weather changes. Freezing may severely damage the heat exchangers and cause an extended outage for thawing and repair. The Neil Simpson Number 5 unit experienced a minor freezeup caused either by a design fault or an operator error. The result was distortion of several finned heat exchanger tubes in a primary condenser section.

Freezeup can be prevented by maintaining the proper balance of air and steam/water so that freezing temperatures are not approached anywhere in the dry cooling tower heat exchanger. Air flow through the dry heat exchanger in the winter can be reduced by either changing fan speed or adjusting a system of louvers. The operation and surveillance of the air flow control system, however, adds a new dimension of complexity to normal plant operations. Furthermore, the dependability of louver operation during driving snow or a freezing rain is questionable.

Freezing can also be prevented by reducing the heat exchange area by draining heat exchanger systems and removing them from service in extreme cold and low load operation. A planned shutdown or loss of load must be followed immediately by the rapid draining of the entire tower into underground storage tanks. It is not known if such a system would be sufficiently flexible to be used on anything but a base load plant.

Plant startup in freezing weather is a very exacting process; the procedure must be planned with precision and executed rapidly and precisely. The steam/water must be heated sufficiently to raise the heat transfer surface to above freezing. The turbine admission values and tower draft must be controlled to prevent either excessive exhaust pressure or freezing tower temperatures during startup.

2.2.4.2 Corrosion

In a direct-condensing or Heller system cooling tower, condensate directly contacts the extensive internal surface area of the heat exchanger tubes, providing a considerable opportunity for chemical interaction (corrosion) and air intrusion. The chemical treatment of the condensate must balance the requirements for both boiler and heat exchangers if the overall plant life is to be maximized. Such balance is not easily accomplished.

In-leakage of air or other noncondensables can result from damage, defective heat exchanger components and connections, or operating conditions such as draining or air introduction to prevent turbine overspeeding following a loss of turbine load. Noncondensables must be continuously and effectively removed or condensation will be adversely affected and/or accelerated corrosion can occur.

Experience at the Neil Simpson Number 5 Unit affirms industry concern regarding air and corrosion problems. Iron oxide is appearing in the boiler and carrying over to deposit on the turbine blading. Excursions of iron content of the boiler water from the "normal" 0.1 ppm to 18 ppm have been observed after startup. These turbine deposits required removal by sandblasting after 2 years of operation. One possible source of this oxide is corrosion of the steel condenser tubes in the dry cooling tower. The exact source of the oxygen and the corrosion site is not known at this time.

2.2.4.3 Dependence on Weather Conditions

The cooling ability of a dry cooling tower depends on the ambient dry-bulb temperature, not the wet-bulb temperature. It is a known phenomenon that the dry-bulb temperature fluctuates over a broader range during a typical day than the wet-bulb temperature. Therefore, the performance of a dry cooling tower will vary over a larger range than wet units. If a peak demand coincides with the highest temperatures, the penalties in heat rate and capacity could be considerable. The strong influence on plant capacity of something as unpredictable as the weather is a disconcerting factor in long-range utility planning activities.

2.2.4.4 Long Term Degradation of Performance

The long-term degradation of the heat transfer performance of fin-tube heat exchangers used in dry cooling tower application can result from several different mechanisms:

- external corrosion and deposition of atmospheric contamination, which forms a surface film of high thermal resistance. This is a potential problem in aluminum-finned heat exchangers which deteriorate considerably in most atmospheres;
- internal corrosion, which causes high thermal resistance fouling on the interior tube surface;
- air flow blockage from the entrapment of lint, seeds, and other airborne materials; and
- corrosion attack and mechanical vibration (fatigue) in the thermal contact between the fins and the body of the tube.

The performance and life span of heat exchangers can be improved by occasional washdowns and mechanical cleaning of solids. Deterioration can be limited by the application of exterior surface coating. At the present time, a number of coatings are being evaluated, but no conclusions have been reached regarding their long-term effectiveness.

The degradation of the thermal contact at the fin root is of particular concern because original performance cannot be easily restored. One vendor described laboratory tests in which an approximate 20% reduction in the overall heat transfer coefficient was experienced in identical tests of a panel performed several months apart. This reduction was attributed to the degradation of the thermal bond between the fin and tube. Although similar events have not been documented in dry cooling towers, the potential for performance degradation certainly exists, especially with spirally-wrapped and grooved-tube configurations.

2.3 DESIGN CHARACTERISTICS

2.3.1 Sizing Dry Cooling Systems for Minimum Cost

The design of dry-cooled power generating stations requires closer integration between the heat rejection system and the steam supply-turbine systems than for water-cooled plants because of the impact of ambient temperature on the performance characteristics of the dry cooling system. As discussed in Section 2.2.4, plant performance decreases as ambient temperature increases; conversely, equipment size (and cost) required to maintain a fixed level of plant performance increases with ambient temperature. Hence, the sizing of the dry cooling system involves rather cost-sensitive tradeoffs in equipment size and plant performance.

Several different approaches can be used to evaluate these tradeoffs. However, they all reduce to developing a cooling-system design based on a selected set of design points (such as the assumed ambient temperature, temperature difference between turbine exhaust and ambient air, and cooling range for the condensate) such that the calculated average cost of bus bar electricity from the plant over the years (taking into account the costs required to obtain power from other sources when the plant output is inadequate) is at a minimum. Since many parameters may be varied during the course of the design, sizing the cooling system involves a complicated optimization process.

2.3.2 Size of Dry Cooling Systems

Most studies of dry cooling systems have been based on use of modular heat exchanger units which have been developed for application to industrial situations other than electrical

power generation. The investigators have assumed that optimization of the heat exchangers for this particular situation would not greatly change the cost projections. The sizes of dry cooling systems quoted in this report are a consistent composite of the results of several of these studies (Ref. 9,10) and thus also do not reflect any effort toward further optimization of the heat exchangers themselves.

Figure 2.7 represents the area of dry cooling modules of the mechanical draft type which would be required to reject heat from generating stations of various sizes. The area noted is the immediate ground area of the modules. Section 2.3.4 below further discusses land area requirements for the total plant layout.

Figure 2.8 represents the power requirements for fans and water pumps for mechanical draft modules operating as indirect systems. A range of power needs is shown because the original study did not attempt to optimize these requirements in the light of various power costs, but simply accepted the design requirements of the modular units.

2.3.3 Impact of Reactor Type on Dry Cooling Systems

The principal impact of reactor type on the dry cooling system is through the combined effect of heat rejection load per unit electrical output and heat rejection temperature. For reactors connected to Rankine cycle expansion systems, the thermodynamic efficiency is of prime importance. If the HTGR coupled to a gas turbine is also considered, the higher heat rejection temperature of the gas turbine is of prime importance, over and above consideration of the thermodynamic efficiency.

Figure 2.7 Area Required for Dry Cooling Modules

Figure 2.8 Power Requirements for Fans and Water Pumps

Light water reactors (LWRs) are inherently less efficient than high temperature gas cooled reactors (HTGRs) and liquid metal fast breeder reactors (LMFBRs); the latter are roughly comparable to fossil-fueled generating plants. The relative efficiencies of these reactors are reflected in the curves shown in Figures 2.7 and 2.8.

Among LWRs, the differences between boiling water reactors (BRWs) and pressurized water reactors (PWRs) as related to dry cooling are not considered significant. A direct system cannot be used with BWRs because of the need to isolate the reactor from the cooling tower. However, a similar (though perhaps smaller) concern exists with coupling a PWR to a direct system; consequently, the use of direct condensation with LWRs is not a viable option.

The use of HTGRs and LMFBRs would reduce the cost of dry cooling because of their higher thermal efficiency and hence lower heat rejection requirements. The most significant impact would result from the adaptation of the HTGR coupled to a gas turbine (Brayton cycle). Because of the much higher heat rejection temperature inherent in this cycle, the cost of dry-cooling would be markedly reduced, perhaps by a factor of two-thirds.

2.3.4 Spacing of Cooling Towers and Land Area Requirements

Lack of knowledge about the ways adjacent cooling towers interact and the air flow behaves in the system makes it difficult for experts in the field of dry cooling to agree on cooling tower spacing and placement. Estimates of the additional area that should be allotted to the system, over and above the area surrounding the module units themselves, range from a factor

of about two to seven. Concern centers on recirculation of the hot plume into the exchanger inlet under certain wind conditions and on the proximity of other structures which could modify the normal airflow patterns. Studies are underway to develop criteria for tower spacing and land area requirements.

2.3.5 Plant Efficiency Versus Ambient Air Temperatures

As previously discussed, the most significant factor in dry cooling is the effect of air temperature on plant output and efficiency. This variation is a function of system design and consequently cannot be closely defined until the design conditions have been stipulated. Figure 2.9 indicates expected plant efficiency based on a particular set of assumed design parameters of air temperature and steam-air temperature difference.

The drop in station output with increasing air temperature leads to the most significant cost element in the dry cooling process; namely, the penalties associated with the need to provide supplemental power on hot days. Probably the most significant step leading to the adoption of dry cooling will be the development of hybrid systems which will provide incremental wet cooling during the short periods when dry cooling is insufficient.

2.3.6 Outlet Air Flow and Temperatures

For the purposes of evaluating the influence of the thermal plume on the environment, Table 2.2 indicates the range of values for the quantity of hot air introduced into the atmosphere, its temperature and the velocity of the plume as it leaves the equipment.

Figure 2.9 Approximate Normalized Plant Output as a Function of Ambient Air Temperature (Based on ITD of 70°F @ 70°F)

TABLE 2.2
RANGE OF VALUES FOR MAJOR PLUME
PARAMETERS FROM DRY COOLING TOWERS

	<u>Induced Draft</u>	<u>Forced Draft</u>	<u>Natural Draft</u>
Range of Exit Air Velocities (ft/sec)	40-60 ft/sec	20-30 ft/sec	15-25 ft/sec
Range of Temperature Rise	(0.5-0.75) ITD*	(0.5-0.75) ITD*	(0.8-0.9) ITD*
Range of Exit Temperature at 70°F ambient; 70°ITD	105°F-123°F**	105°F-123°F	126°F-133°F
Range of Air Flow ft ³ /sec per 1000 MWe (Nuclear)	2.2x10 ⁶ -3.3x10 ⁶	2.2x10 ⁶ -3.3x10 ⁶	1.8x10 ⁶ -2.0x10 ⁶

*Where ITD is the difference between condenser hot well temperature and the ambient temperature.

**These increase with ambient temperature.

2.4 OPERATIONAL EXPERIENCE

Operational experience with dry-cooled power plants is limited in this country to that of Black Hills Power and Light's Neil Simpson Units 4 and 5, located at Wyodak, Wyoming. Neil Simpson 5 is a 20 kW unit cooled by a direct cycle arrangement. Neil Simpson 4, which served as a pilot plant, is a 3 MW unit with a similar system.

Foreign experience with dry-cooled systems is much more extensive. While dry-cooled plants are the exception rather than the rule overseas, the fact that utilities are generally winter-peaking and thus do not suffer severe penalties from loss of capability in the summer has brought more ready acceptance of dry cooling. Reports summarizing operating experience in Western Europe and at the Razdan plant in Soviet Armenia, which is the largest plant in the world equipped with dry cooling, will be issued shortly.

The Razdan plant is 800 MW built in modules of 200 MW each and totally cooled by indirect cycle natural draft towers. Dry cooling operation at this plant has been basically no more troublesome than an evaporative system. Razdan experiences very severe temperatures in the winter, down to -35°C , and during initial startup there was some damage from freezeup of the condensate. After gaining a better understanding of the temperature gradients that occur within the air-cooled heat exchanger cross-flow arrangement and improving the monitoring of the condensate temperatures, this difficulty was remedied. Operators of the Razdan plant continue to study ways to improve the instrumentation and predict the freezeup margin under a variety of extreme weather conditions.

Startup of the heat rejection system appears to proceed smoothly and the load-following capability of the tower, provided by sectionalized nuclear systems, seems able to provide the required dynamic response to prevent thermal fatiguing of the last stage of the turbine. Plant availability has been over 95% and no down time has been directly attributable to the heat rejection system after correction of the freezeup system (described above) approximately 2 years ago. The heat exchanger surfaces are cleaned approximately once a month by an external blast of high-pressure steam which is required to remove a fine dust of cement carried to the surfaces from an adjacent cement plant. There is little or no evidence of external corrosion on the galvanized aluminum fins of the Heller-Forgo heat exchanger surfaces. There was some evidence of deposition of iron oxide on the inside surface of the aluminum tubes. As a consequence, a program is underway to cover the inside surfaces of the steel water lines to the towers with an aluminum metalized paint, to provide a uniform aluminum surface for the condensate system.

The new water chemistry control scheme will shortly be adapted at the Razdan plant as a result of experience at a similar, but smaller, dry-cooled plant in Hungary. The system uses essentially neutral water (pH 7.2) containing very low total solids. The low total solids are maintained through the use of a mixed-bed ion exchanger and a full-flow filter which periodically polishes the condensate. The oxygen level in the system is also carefully controlled. With this method of operation, it is claimed that no blow-down is required.

2.5 PROSPECTS FOR IMPROVING DRY COOLING SYSTEMS

2.5.1 Costs

The reduction of overall power generation costs involves a simultaneous consideration of:

- heat transport and storage in the entire plant and its effect on overall plant thermodynamics;
- manufacturing and erection costs as they affect the total investment in heat sinks and associated auxiliary equipment;
- maintenance, operating and fuel costs;
- reliability and durability as they affect plant availability and tower life;
- power demand cycles and power grid interactions;
- capability penalties resulting from high ambient temperatures; and
- plant operability.

The improvement of one or more of these factors will not necessarily result in the improvement of overall costs if it causes the other factors to be less favorable. In other words, improvements made in any of the above factors through research and development must be tested by determining their influence on overall costs through the system and plant optimization process. A number of advanced or innovative systems may show promise for reducing costs, improving performance, or ameliorating the special problems of dry cooling.

Advanced and innovative approaches which show promise for improving basic dry cooling tower performance include:

- optimization of present dry cooling designs specifically for central station use (most dry coolers at present are used in other industries);
- development of unique heat transfer surfaces (e.g., fluidized beds, plastic tubing, uniquely fabricated extended surfaces); and
- phase change fluid transfer of heat from the turbine to the dry cooling tower by evaporation and subsequent condensation.

More than half of the dry cooling tower cost penalties result from reduced plant output on hot days (as discussed in Section 2.2.1). The following trim cooling approaches are being evaluated to reduce this penalty:

- a wet-dry hybrid system, with a small wet tower to supplement the dry tower at peak temperatures;
- special condenser unloading schemes (i.e., bleeding steam off at higher temperature from the last stage of the turbine or using heat pumping approaches (such as a steam jet or ammonia absorption refrigeration) to reject heat in the tower at a higher temperature;
- advantageous use of heat kinetics in, for instance, feedwater, heating, and other parts of the thermodynamic cycle; and
- use of capacitive ponds to store "negative enthalpy" (i.e., cooling capacity for need at peak daytime temperatures). This results in a substantial savings in the size of the dry cooling tower and/or reduction in the size of trim cooling apparatus needed.

Several of these approaches have already received considerable study and show promise of reducing overall power penalties associated with dry cooling towers.

The hybrid wet-dry system looks attractive enough to warrant the special attention of utilities and designers of heat sink equipment.

These approaches also benefit the turbine since peak back pressures can be held to 8 to 9 in. HG in many instances if these trim cooling schemes prove practical and cost-effective.

Summarizing, the cost penalties presently associated with dry cooling are expected to be substantially reduced by intensive efforts underway to improve basic dry cooling tower performance and to limit or eliminate the hot weather capability penalty presently encountered. A comprehensive review of central station heat transport and storage dynamics would be valuable to the second effort.

2.5.2 Advanced Concepts Under Development

Since the main deterrent to the widespread acceptance of dry cooling by utilities is the high cost of electricity from such generating plants, considerable effort around the country is directed toward reducing these costs. Approaches which are receiving the most attention are briefly described in the following sections.

2.5.2.1 Dry/Wet Hybrid System

The hybrid cooling power plant would have reduced sensitivity to ambient temperatures, reduction in size and cost of cooling towers, and lower fuel consumption. The primary incentive for hybrid systems is that they reduce the penalties associated with inadequate power production on hot days, while requiring the minimum possible use of water.

The wet towers would operate only at certain ambient temperatures. For this case, the wet towers would need only enough capacity to provide the necessary cooling to augment dry tower capacity. Conceivably they could be incorporated in the dry cooling systems.

In addition to conventional combinations of wet and dry towers, at least two others hold some promise: deluge cooling and adiabatic cooling. In the former, a thin film of water is maintained over the heat exchanger surface to promote the overall heat transfer coefficient. In the latter, water is used to humidify and cool the warm air down to its saturation temperature. Both of these methods could be used in dry towers when the ambient conditions exceed the design conditions.

2.5.2.2 Capacitive Systems

The classification "capacitive system" includes concepts which augment cooling on hot days by use of an auxiliary heat sink, such as a large closed reservoir of water (or possibly whatever auxiliary reservoir is required for emergency core cooling heat rejection for nuclear reactors). It is envisioned that this heat sink would be sufficient to absorb heat in excess of that which can be dissipated by the dry tower for the few hours the ambient temperature exceeds the design heat rejection temperature. The reservoir would then be cooled back down to some base temperature during evening off-peak hours.

The main disadvantage of the capacitive cooling system is cost. This must be balanced against the value of enhanced system capability on hot days for peak power demands.

A number of such capacitive cooling concepts are being considered, including use of

- a pond or cistern of cooled water,
- cooled rocks or solids,
- ice or other phase-change material, and
- phase changes inherent in a cooling process for storage.

The best system for a particular application depends on the method being employed to produce the cooling effect and the particular dry cooling tower concept under consideration.

Some cooling methods make use of:

- excess cooling tower capacity at night,
- the radiative shallow pond,
- the ammonia absorption heat pump,
- steam ejector chillers,
- mechanical compressors driven by a turbine shaft,
- direct air circulation, and
- small auxiliary cooling towers.

Specific dry cooling schemes may point toward a unique combination of storage and chilling (trim cooling) method. However, the economics will, in general, favor using water to store sensible heat or possibly latent heat through freezing to ice. (Ref. 14)

It seems highly likely that some capacitive effect will be used in conjunction with dry cooling towers to avoid some of the hot day capability penalty which may otherwise result from the necessity to "throttle back" the power generating station to lower outputs at higher operating ambients.

2.5.2.3 Intermediate Heat Transfer Fluid - Ammonia Cooling

There have been several studies of the use of alternate working fluids as a bottoming cycle below a high-temperature steam expansion cycle. The advantage lies in the lower specific volume of these working fluids and the subsequent reduction in size of equipment at the low temperature end of the expansion cycle. Although a recent study by Franklin Institute indicates a marginal economic incentive for the combined cycle in conjunction with dry-cooling, it does identify the potential for using ammonia, or other intermediate fluids, as a heat transfer medium between the steam condenser and the dry-cooling tower without expansion. Again, the advantage is the high specific volume of the alternate fluid which allows more convenient arrangement of a direct condensation process in the air-cooled heat exchanger, together with the isolation of this portion of the system from the condenser and concomitant avoidance of de-aeration problems. Conceivably savings would accrue in the design of the surface condenser (condensation of the steam and boiling of the ammonia), the piping system which carries the ammonia vapor to the cooling tower and returns the liquid ammonia to the surface condenser, and the pumping costs associated with this fluid transfer. The use of ammonia with the added feature of an ammonia absorption cycle has been proposed by Power Generation Cooling Systems, Inc. of Seattle. It is claimed that such an arrangement could provide augmented cooling capability for the hottest days and result in the use of normal back-pressure turbines.

2.5.2.4 Plastic Pipe Heat Exchangers

The use of extruded plastic pipe of such low cost that extended surfaces need not be considered has been proposed by Professor C. Roma of the University of Rome. The resulting design

concept has been based on the following premises: 1) the heat exchanger will be designed for very low pressure drop to allow the use of natural draft for air movement; 2) because of the resultant low air velocities, the heat transfer coefficient will be very low and surface areas must be very high; 3) the heat exchanger surface must be very inexpensive in view of the large surface area required; and 4) assembly methods must also be very inexpensive because of the large number of tubes required. These assumptions have led to some unique approaches to the design and construction of the plastic heat exchanger concept. The claim has been made that a cooling tower capable of maintaining back pressures equivalent to that of evaporative cooling towers can be constructed at competitive cost.

2.5.2.5 Fluidized Bed Heat Exchangers

The fluidized bed heat exchanger consists of a shallow bed of small particles which are caused to float, or fluidize, by forcing air passing through the bed. Uniformly spaced tubes containing heated water from the plant are placed horizontally in the fluidized bed. Heat is transferred through the tube walls out into the fluidized bed, where the air is sensibly heated and exhausted to the atmosphere. The fluidized bed's ability to transfer heat is higher than that of a standard design where air is passed over finned tubes. Heat transfer augmentation is realized mainly due to the destruction or reduction of the boundary layer around the tubes caused by the presence of particles; thus the rate of heat conduction is increased. (Ref. 15)

The most significant attraction of fluidized bed heat exchangers is their high overall heat transfer coefficients, due to the

presence of the fluidized bed. If these enhanced coefficients sufficiently reduce the cost of heat rejection without creating significant technical problems, the fluidized bed concept should be seriously considered as an alternative to standard dry cooling techniques and conventional wet cooling methods.

Three variations on the fluidized bed heat exchanger are being considered for application to dry cooling heat rejection. Both finned and smooth tubes can be used in the bed. Also, the fluidized bed can be operated partially wet to dissipate heat both by sensible heating of the air and evaporation of water. (Ref. 16) These variations or combinations of these have high potential for economic heat rejection.

Current results indicate that two factors are important to the success of the fluidized bed heat exchanger. The first is the design of a system which yields high overall heat transfer coefficients. The second is the reduction of fan pumping requirements for the air. Optimization of these two factors will provide a promising heat rejection system which is technically feasible and economically competitive.

2.5.2.6 Periodic Heat Exchanger

Workers at MIT are developing a concept which they claim will greatly reduce the capital cost of dry-cooled heat exchangers. (Ref. 17) It uses the principal of cooling the warm condensate by contacting it with a cooled surface which is rotated through the liquid and then subsequently cooled by air passing over the surface. The configuration is a multitude of discs rotating through a trough containing the condensate which covers a lower portion of the disc. Air blowing over the top

of the trough cools the discs as they rotate out of the water. Wetting of the discs and the consequential loss of water by evaporation are reduced by covering the water in the trough with a nonvolatile oil. The claim is made that a heat rejection system of this configuration can greatly reduce capital cost.

2.6 DCNEC REPORT ASSUMPTIONS

For the purposes of analyzing the DCNEC concept, the following assumptions have been made in the surrogate site study:

- The DCNEC is composed of 12 reactors, each with a generating capacity of 1200 MWe.
- Construction of the DCNEC would commence in 1985, with one reactor being completed each year for 12 years.

REFERENCES FOR SECTION 2

1. K. A. Olesen, et al. "Dry Cooling for Large Nuclear Power Plants." Westinghouse Power Generation Systems Report GEN-72-004, February 1972.
2. J. D. Rossi, et al. Cost Comparison of Dry-Type and Conventional Cooling Systems for Representative Nuclear Generating Plants, March 1972.
3. "Comparison of Wet and Dry Cooling Towers for Colstrip Units No. 3 and 4." Bechtel Corporation Report prepared for Montana Power Company, May 1974.
4. D. E. McFeran. "Dry Cooling Tower Economic Study." Report to Seattle City Light, Project 72-4, April 1973.
5. "Dry Cooling Towers Study." Bechtel Corporation Report prepared for WEST Associates, April 1971.
6. W. J. Westre. "U.S. Experience With Air Cooled Condensers." Paper presented to the American Power Conference, Chicago, IL, April 1971.
7. R. Turvey. Optimal Pricing and Investment in Electricity Supply. MIT Press, Cambridge, MA, 1968.
8. P. L. Joskow and M. C. Baughman. The Future of the U.S. Nuclear Energy Industry. MIT Energy Lab Report #MIT-EL 75-006, April 24, 1975.
9. J. W. Currie. Short Run Average Cost Estimation of Electrical Power With Reference to Dry Cooled Technology. Battelle-Northwest, Richland, WA, in press.
10. F. C. Olds. "Nuclear Standards and Standard Nuclear Plants: More Than Money is at Stake." Power Engineering, March 1975.
11. Heat Sink Design and Cost Study for Fossil and Nuclear Power Plants. WASH 1360, United Engineers, December 1974.
12. Assessment of Energy Parks vs. Dispersed Electric Power Generating Facilities, Final Report - Volume II. Center for Energy Systems, General Electric Company, May 30, 1975.
13. General Electric Company, Marketing Information Letters 922, 946 and 1017.

14. J. Baughn and A. Jackman. "Solar Energy Storage Within the Absorption Cycle." Paper No. 74-WA/HT-18, August 1974.
15. B. R. Andeen, L. R. Glicksman, and W. M. Rohsenow. Improvement of the Environmental and Economic Characteristics of Cooling Towers. Massachusetts Institute of Technology, Energy Lab Report No. MIT-EL-74-007, June 1974.
16. B. R. Dickey, E. S. Grimmett, and D. C. Kilian. "Waste Heat Disposal Via Fluidized Beds." Chem. Engr. Progress, 70, 1, January 1974.
17. P. C. Hon, J. C. Hon, et al. "Improvement of the Environmental and Economic Characteristics of Cooling Towers, Part II, Periodic Cooling Towers." MIT-EL-74-D08.

3.0 SURROGATE SITE SELECTION PROCESS

This selection process for a DCNEC surrogate site consisted of the following phases:

- A coarse screening of approximately the western half of the contiguous United States to identify relatively large areas, on the order of 10,000 square miles or more in size, with a high potential of containing suitable sites for a DCNEC;
- analysis of the characteristics of each of the surrogate regions identified in the coarse screening process to determine which area would be most suitable for use in an analysis of a dry-cooled nuclear energy center; and
- selection of a surrogate site within the preferred region approximately 600 square miles in size, which is approximately ten times larger than the area actually required for siting a nuclear energy center. (A relatively large site was selected because, for purposes of the surrogate analysis, a smaller site is not needed and the selection process was not sufficiently detailed to identify a smaller site).

4.0 CONSIDERATIONS IN SITE SELECTION

4.1 SUMMARY OF COARSE SCREENING

Coarse screening criteria developed by the Oak Ridge National Laboratory for the Nuclear Energy Center Site Survey were used in the initial selection of surrogate regions, except that the constraint requiring water resources adequate for wet cooling was relaxed. The primary factors considered in the DCNEC coarse screening process were:

- seismic suitability
- water availability (attention was focused on areas with water resources that would likely be inadequate to support operation of wet-cooled nuclear energy centers)
- population distribution and density
- areas of dedicated land use, such as national parks and wildlife refuges, which were excluded from consideration
- locations of major load centers

Consideration of these factors, as well as comments from four major electric utilities serving the western United States, resulted in the selection of the four surrogate regions shown in Figure 4.1.

In the sections that follow, these regions are analyzed on the basis of the generic considerations involved in DCNEC siting. These considerations incorporate detailed study of the coarse screening factors listed above and also include analysis of:

- existing transportation routes for movement of heavy equipment,
- climatology,

- existing ecological communities, and
- institutional constraints.

<u>Region</u>	<u>Designation</u>
1	Southeastern Oregon/Southwestern Idaho
2	Eastern Nevada/Western Utah
3	Lower Colorado River
4	Eastern Sacramento Valley

Figure 4.1 Surrogate Regions Selected for Potential DCNEC Suitability Analysis

4.2 TRANSPORTATION NEEDS

4.2.1 Shipment of Major Power Plant Components

Present-day nuclear steam generation and turbine-generator systems, and those anticipated for future use, involve the fabrication, transportation, and installation of very heavy, large components (Table 4.1). Although the majority of light water reactor components are readily transported by conventional means, some larger ones present special problems when considered for a DCNEC. Waterborne transport routes, the conventional mode of shipment, generally do not exist in arid regions where these centers would be located. Therefore, it is necessary to analyze component transport characteristics, as summarized below.

TABLE 4.1
SIZE OF LARGEST LIGHT WATER
REACTOR COMPONENTS

<u>Component</u>	<u>Length</u>	<u>Width</u>	<u>Net Weight</u>
Reactor Vessel*	62'-10"	26'-10-1/2"	760 tons
Steam Generator	73'-1-3/4"	12'-11"	504 tons
Wound Stator**	37'-11"	14'-1"	474 tons

*Weight without head; dimensions over nozzles

**When carried on Schnabel cars, total weight on rails is 770 tons and length over couplers is 175 feet

4.2.1.1 Steam Generators

A typical steam generator for a light water reactor is approximately 73 feet long and 13 feet in diameter and weighs in excess of 500 tons. Despite this bulk, transport by a conventional rail system is possible over carefully selected routes. In general, rail transport for such loads is limited to maximum grades of 1-1/2 percent, with refusal of the rail companies to assume liability for transportation on grades exceeding 2 percent. In addition to the grade constraints, right-of-way dimensional limitations may be imposed by such facilities as tunnels and bridge trestles. For loads as large as steam generators, the track curvature encountered must generally be greater than 225 feet. The maximum width of a steam generator that can be transported by rail is generally limited to approximately 13.5 feet.

4.2.1.2 Steam Turbines

Steam turbines, although extremely large, pose no unique transportation problems as onsite assembly is currently a common and reliable method of fabrication.

4.2.1.3 Electrical Generators

The largest component of a 1200 MWe electrical generator, the wound stator, is typically about 38 feet long and 14 feet wide and weighs approximately 475 tons. The wound stator can be transported by rail using Schnabel cars, subject to the same restrictions on track grade and curvature mentioned for steam generators. In addition, the rail route must be able to accommodate the 14-foot stator diameter.

4.2.1.4 Primary Reactor Vessels

Rail transportation of large primary reactor vessels of the 1200 MWe size has not been attempted due to the combination of large dimensions and weights. These vessels can reach 63 feet in length and 27 feet in diameter and can weigh more than 750 tons. Three alternatives are available for shipping this component to a DCNEC:

- 1) Establishment of a wide-gage, fixed-rail right-of-way from the DCNEC site to a point with access to barge transportation.
- 2) Use of novel approaches, such as helium-filled air transporters, that are now being developed for loads up to 100 tons.
- 3) Use of a recently-developed method for onsite assembly from preformed shapes transportable on conventional railroad lines or by trucks.

The alternative selected depends on site-specific factors, but Alternative 3 appears to be the most promising. At a nuclear energy center, the option of onsite fabrication may be economically feasible, considering that a multi-year market will exist for such work.

4.2.1.5 Short Distance Component Transport

Transport of large (up to 1400 tons) components overland for short distances (current practice is 10-30 miles) can be accomplished with tracked transporters on grades of up to 10 percent. Only rudimentary road beds are necessary and a 25-foot horizontal clearance is required.

Rubber tired transporters can be used on grades of up to 2 percent, but use of public highways is generally precluded by state laws. Movement rates are slow (1 mile per hour maximum) and the cost is high, on the order of \$500,000 per mile.

4.2.2 Region Evaluations

Each of the study regions can be evaluated in light of this shipping analysis for major power plant components. An additional point should be made, however. The overriding parameter in the coarse screening phase of the transportation analysis is shipment of the major components. However, during the site-specific study the analysis must also deal with the ability of local transport links to provide for routine operational shipment of materials and equipment and to accommodate construction force commuter traffic.

4.2.2.1 Region 1: Southeastern Oregon-Southwest Idaho

- No waterborne transportation is directly available. The closest approach by barge would be on the Columbia River at Boardman, Oregon. This location would involve several hundred miles of overland transportation.
- Rail access to this area (represented by Rome, Oregon) is not available. Nearest rail heads are Winnemucca to the south (connecting to Ogden and Salt Lake City, Utah) and Boise, Idaho to the north, with routings possible from Pocatello and Salt Lake. Additional overland transport on the order of 100 to 200 miles would be involved. The preferred routing would probably involve a new 100 to 200-mile rail spur north from Winnemucca, Nevada.

4.2.2.2 Region 2: Eastern Nevada - Western Utah

- No waterborne transportation is directly available.
- Rail transportation is available in the southern part of this region from the Los Angeles/Long Beach area through Las Vegas and from Salt Lake City. The northern part of this region is served by the Western Pacific and Southern Pacific railways, with the routing west of Salt Lake and Ogden passing through Wells and Elko, Nevada. A secondary spur line runs south from Wells to Ely, Nevada. New north-south trending railroad spurs would permit consideration of large areas.

4.2.2.3 Region 3: Southeastern California - Western Arizona

- No waterborne transportation is directly available; the closest approach would be the Los Angeles-Long Beach Harbor or San Diego.
- Rail access to this area (represented by Needles, California) is available from the west via Barstow, San Bernadino, Los Angeles/Long Beach. Access from the east is possible from Phoenix and Flagstaff, Arizona.

4.2.2.4 Region 4

- Waterborne transportation is available to the southwestern edge of the region through San Francisco Bay and up the Sacramento River delta to Sacramento and Stockton.
- Rail access is available from barge facilities running north-south along the central section of the Sacramento

and San Joaquin Valleys. Also, two rail lines run easterly through the central portion connecting San Francisco with Sacramento, Stockton and Reno.

4.3 TRANSMISSION

4.3.1 Summary

Characteristics of a system for transmitting electric power from a DCNEC would be determined by:

- the location of the loads relative to that of the DCNEC;
- the nature, ownership, and current use of the land over which the transmission lines would pass and the difficulties encountered in satisfying environmental and reliability requirements through selection of routes and line designs;
- bulk power transmission systems that would already be in place in the region of the DCNEC transmission and loads in 1985; and
- the advance plans of the utility or utilities serving the region with respect to future nuclear or other types of generating plants and future additions to bulk power and subtransmission systems.

This study assumes 1) that the plans of the utilities for expanding their generation and transmission facilities during the period 1975-85 will be implemented, 2) that the DCNEC will begin commercial generating services early in the study period, and 3) that any differences in the transmission system between that which would accommodate the DCNEC and that which may be expected to develop with conventional expansion of generation at dispersed sites would begin to appear in 1986.

The transmission systems discussed in this section, and the specialized systems presented in Section 5.3 and Appendices A.2 and A.3, are examples of the facilities that may be required by DCNECs. They have been developed for the purpose of evaluating the impact of transmission on the overall feasibility of the DCNEC concept.

4.3.2 Projected Loads

Electrical energy supplied from DCNECs in the surrogate regions could be used conveniently in California, Arizona, Nevada, Utah, and possibly the Pacific Northwest. However, the load centers in northern California, southern California, and Arizona are the most prominent in this analysis and thus are the focus of discussion. New generating capacity requirements for these centers based on load growth forecasts for the period 1985-2000 are listed in Table 4.2. Projections for other western regions, as well as a discussion of demand analysis, may be found in Appendix A-1.

TABLE 4.2
ESTIMATED NEW CAPACITY REQUIREMENTS,
INCLUDING RESERVES

Area	Capacity, Gw	
	1985-95	1985-2000
PSA*		
46 San Francisco	25	32
47 Los Angeles-San Diego	22	28
48 Arizona	<u>8</u>	<u>10</u>
	55	70

*Public Service Areas of the Federal Power Commission

A substantial portion of these capacity requirements may be met by nuclear plants. In utility advance plans for central and northern California, 88% of new capacity to go into service from 1985 to 2000 is expected to be nuclear. Commitments to nuclear capacity in southern California are less certain for reasons of water availability and political and regulatory trends. In that area and in Arizona, Utah and New Mexico, there has been increasing dependence on coal-fired plants for new capacity in the 1975-85 period.

These capacity requirements will be met by a variety of plant types; nuclear and nonnuclear, base load and peaking. However, the requirements are large enough that it may be presumed that if the comparative economic positions of the alternate plant types remain unchanged, the electricity generated from a 12-reactor DCNEC could easily be utilized by the load centers.

4.3.3 Existing Systems

The existing major utility systems in California and Arizona have or plan 500 kV systems and interconnections and expect to increase their own bulk transmission system capacity at 500 kV in the foreseeable future. One existing ± 400 kV DC line from The Dalles to Los Angeles is used for available off-peak generating capacity, to carry surplus hydro energy for displacement of thermal energy, and as a firm capacity resource for the California utilities. It is also available for emergency south-north power transfer.

The West Coast transmission system forms part of an interconnected loop surrounding the State of Nevada. The generating and transmitting capacity of the eastern part of the loop is relatively low. The Las Vegas region is at the southern end of the loop, where the density of major generating stations and transmission lines is relatively high. Power flow in that general area is from the Four Corners, Navajo, Hoover Dam, and Mohave Plants westward to the southern California loads and southward to Arizona loads.

The characteristics of the transmission system in 1985 will have a bearing on DCNEC transmission requirements. The high-capacity grid and its associated generating resources in place then may:

- provide alternate emergency paths for flow of DCNEC power, thus reducing the number of new lines required for reliability purposes;
- provide opportunity for better use of transmission facilities through power flow displacement;
- minimize problems of obtaining right-of-way if low-capacity transmission lines in existing corridors can be replaced by high-capacity lines while maintaining adequate service conditions during the construction period;
- provide opportunities for flow of power from alternative dispersed plants into the system without extensive accompanying system reinforcements; and
- provide suitable points in subtransmission systems at which an overlay bulk power system could terminate with minimum station modifications.

However, the scope of this study has allowed only a very superficial consideration of the relationship with existing systems; the concepts to be described are assumed to be independent, except for use of subtransmission feed points and backup support to isolated load centers on the DCNEC transmission system.

The 500 kV system anticipated for 1985 is indicated in Figure 4.2. Although the "overlay" 500 kV systems for DCNECs are assumed to be independent of the then-existing bulk power system for purposes of this preliminary study, they would in fact be integrated with it. The integration may benefit transmission from a DCNEC source more than from a given set of dispersed alternative sources. This question could be pursued in any future followup investigation of a site of interest.

Figure 4.2 Major Transmission Lines - 1985 kV Accented

Figure 4.3 includes the portion of the system in the vicinity of the Region 2 overlay. The existing transmission systems have numerous lines at lower voltages as shown in the background.

4.3.4 DCNEC Switching Station

Examples of a DCNEC plant layout and its switching arrangement are given in Figures 4.4 and 4.5. The plant contains twelve 1200 MW units with a total nameplate rating of 14,400 MW, with 8 to 10 outgoing 500 kV AC lines terminating in breaker and-a-half switching positions or 5 to 6 outgoing ± 600 kV DC lines with terminal equipment.

4.3.5 Technical Assumptions and Bases

In this preliminary study, the following assumptions and bases were adopted for use in formulating the DCNEC transmission concept. With these criteria and the information outlined in the previous parts of this section, a site-specific transmission system analysis can be made.

- Except as noted earlier, the transmission described herein is assumed to be an overlay system that, on the whole, does not depend on the then-existing 1985 system for emergency support. Flow of power over the DCNEC overlay is assumed to be controlled at the DCNEC generators in estimating load flows and transmission losses.
- Transmission largely will use existing technology, EHV AC and HVDC, for the time period under study. Application of DC transmission has been assumed for distances greater than 450 miles. The AC transmission concept described herein would have lines ranging from 120 to 460 miles in length and a voltage of 500 kV AC. The

Figure 4.4 Conceptual DCNEC Plan Typical Spacing of Transmission Switching Stations

Figure 4.5 Representative Switching Arrangement
DCNEC Transmission Line Terminals

three-DCNEC complex to be discussed later would make extensive use of ± 600 kV DC. Since 1100-1200 kV AC and ± 600 -1200 kV DC are likely to be proven technologies in the next decade, they are assumed to be available, although AC voltages above 500 kV were not selected for this study.

- Maximum load assumptions are:

<u>AC</u>	<u>GW</u>
500 kV double-circuit high-capacity	5.0
500 kV single-circuit high-capacity	2.5
500 kV single-circuit standard-capacity	1.5
<u>DC</u>	
± 400 kV, 400-1000 miles	2.0
± 600 kV, 400-1200 miles	5.0

Series compensation will be applied as necessary to keep the maximum displacement across the AC transmission lines less than $30-35^\circ$ as the DCNEC transmission system loads up.

- Generating station configurations will be arranged to limit the maximum fault current to 62 kA and an outage of any single transmission system element would not take out more than 10% of the DCNEC capacity. High-capacity circuit breakers of interrupting ratings up to 62 kA and opening times of 1 cycle are assumed to be available for the 500 kV buses at these DCNECs. Existing R&D into current-limiting devices and synchronous breakers may be sufficiently advanced to influence the decisions on station and bus configurations where fault current magnitudes otherwise could reach very high levels during the later stages of such DCNEC development.
- Undergrounding will be limited to compressed-gas-insulated cable for the distances and capacities expected and should present viable solutions within 10 years at line crossings,

urban areas and in congested locations. The cost of undergrounding in one congested corridor is included in the Galt and Four Corners transmission estimates.

- System planning for reliability assumes sufficient transmission capacity into the main load areas to permit 1) a permanent outage of any transmission circuit, coupled with a successful reclose on a second circuit after a line-to-ground fault, and 2) a three-phase fault at any location without circuit restoration. Each major load area is supplied through at least three major receiving stations.
- Maximum advantage will be taken of the most modern state-of-the-art control techniques.
- Adequate and reliable provision will be made for station and auxiliary power supply needs at each of the DCNEC generating plants.
- It is assumed that the additions to the bulk power transmission system for a DCNEC will not aggravate the problem of circulating currents now being encountered in the western loop any more than would the potential effects of alternative dispersed plant inputs to the transmission system.
- With reference to the problem of subsynchronous resonance now appearing in some of the longer lines with series compensation transmitting power from coal-fired plants, it is assumed that subsynchronous frequencies originating in the four-pole generators of nuclear plants will be less troublesome than those of the two-pole generators, and any filtering required will not represent a significant cost factor in the rough estimates given in this report.

4.4 INSTITUTIONAL CONSTRAINTS

Institutional constraints existing within the states of the study area eliminate certain regions from consideration. These constraints are generally of two types; one relates to dedicated land use conflicts (such as national or state parks) and the other to state laws that regulate power plant development.

4.4.1 Siting Constraints Imposed By State Regulations

Of the states with areas within the surrogate region boundaries, only Oregon has adopted regulations that geographically delineate areas considered suitable for nuclear power plants.

Areas classified as "suitable" and "unsuitable," as adopted by the Oregon Nuclear and Thermal Energy Council (ONTEC), are shown in Figure 4.6. Superimposed upon the figure is the general Region 1 boundary being considered in this report. As can be seen in Figure 4.6, considerable blocks of Region 1 are designated as unsuitable for nuclear fuel power plants by ONTEC. The significance of the designation, quoting from ONTEC published regulations, is:

"The Council will not accept applications for site certificates for sites within areas designated as 'unsuitable' for location of thermal power plants."

The "unsuitable" classification is based, for the most part, on the desire to protect and preserve southeastern Oregon's natural resource areas, including:

- national parks, monuments, and memorials
- wilderness and roadless areas

Figure 4.6 Oregon Suitability Classifications
for Nuclear Power Plant Siting

- botanical and geologically sensitive areas
- wildlife management areas and refuges
- migratory feeding areas
- state parks
- special fishery resource areas
- historic and scenic areas
- research natural areas

An additional regulation adopted by ONTEC is that the total agricultural land in Classes I through VI (according to U.S. Soil Conservation Service classification) removed from productive capability by the development of thermal power plants and associated facilities shall not exceed 25,000 acres. This total applies to all of Oregon east of the crest of the Cascade range and includes site certificate applications currently in process.

That regulation alone would preclude development of a nuclear energy center on Classes I through VI agricultural land. As envisioned in this report, a nuclear energy center would encompass about 60 square miles (38,400 acres) or more area than allowed by the regulation, if it is agricultural land.

Figure 4.7 shows major blocks of land within these classes for Region 1. Smaller scattered tracts also exist within the NEC area boundary.

Regulations of other states within the surrogate areas are much more general, in that they provide basic guidelines but do not delineate specific areas where they apply. Most are statutes applicable to public utilities. An example of the factors to be considered in determining the suitability of a plant site is the following Arizona Statute governing the Power Plant and Transmission Line Siting Committee:

Figure 4.7. Irrigable Land, Region 1

"A. The committee may approve or deny an application and may impose reasonable conditions upon the issuance of a certificate of environmental compatibility and in so doing shall consider the following factors as a basis for its action with respect to the suitability of either plant or transmission line siting plans:

1. Existing plans of the state, local government and private entities of other developments at or in the vicinity of the proposed site.
2. Fish, wildlife and plant life and associated forms of life upon which they are dependent.
3. Noise emission levels and interference with communication signals.
4. The proposed availability of the site to the public for recreational purposes, consistent with safety considerations and regulations.
5. Existing scenic areas, historic sites and structures or archaeological sites at or in the vicinity of the proposed site.
6. The total environment of the area.
7. The technical practicability of achieving a proposed objective and the previous experience with equipment and methods available for achieving a proposed objective.
8. The estimated cost of the facilities and site as proposed by the applicant and the estimated cost of the facilities and site as recommended by the committee, recognizing that any significant increase in costs represent a potential increase in the cost of electric energy to the customers or the applicant.
9. Any additional factors which require consideration under applicable federal and state laws pertaining to any such site.

B. The committee shall give special consideration to the protection of areas unique because of biological wealth or because they are habitats for rare and endangered species.

C. Notwithstanding any other provision of this article, the committee shall require, in all certificates for facilities that the applicant comply with all applicable nuclear radiation standards and air and water pollution control standards and regulations, but shall not require compliance with performance standards other than those established by the agency having primary jurisdiction over a particular pollution source."

4.4.2 Dedicated Land Use

Land areas within each of the potential surrogate areas considered in this report that are dedicated for special uses are shown in Figures 4.8 through 4.11. These areas, as determined from the National Atlas of the United States, include:

- Indian reservations
- game refuges
- national wildlife reserves
- national monuments
- national forests
- national parks

With the possible exception of some parts of the national forests, these areas are not considered to be available for DCNEC sites because of their existing dedicated uses. Also, any DCNEC development should consider the location and proximity of any dedicated areas, to avoid any detrimental impacts or health and safety hazards to users of the dedicated areas.

Figure 4.8 Dedicated Use Areas, Region 1

Figure 4.9 Dedicated Use Areas, Region 2

Figure 4.10 Dedicated Use Areas, Region 3

Figure 4.11 Dedicated Use Areas, Region 4

4.5 SEISMICITY

Safety considerations preclude the siting of nuclear facilities in areas of high seismic activity. Ground accelerations generated by earthquakes can damage structures inadequately designed to handle the resulting stresses. Incorporating proper safety factors into the design becomes costly when potential accelerations are high. Costs can also rise if the site chosen is in an area where seismic risk determination is a difficult and complicated process. It is important in choosing a site for a DCNEC to select a region in which seismic risk is minimized and the determination of this level of seismic risk is feasible.

4.5.1 Seismic Risk

Figure 4.12 shows the division of the United States into four zones of seismic risk: Zone 0, areas of no reasonable expectancy of earthquake damage; Zone 1, expected minor damage; Zone 2, expected moderate damage; and Zone 3, areas where major destructive earthquakes may occur. (Ref. 1) The seismic risk assigned to these zones is based on the distribution of modified Mercalli intensities associated with the known seismic history of the United States, strain release in the United States since 1900, and the association of strain release patterns with large-scale geologic features believed to be related to recent seismic activity. (Ref. 1) It should be noted that frequency of occurrence was not considered in rating the risk zones. The seismic risk map indicates the maximum expected events, not how often they can be expected to occur. The maximum expected seismic event is an important factor in designing structures in a DCNEC.

Figure 4.12 Seismic Risk Map of the United States
(Modified from Algermissen, 1969)

4.5.2 Seismic Suitability

A map (Figure 4.13) has been published by the Nuclear Regulatory Commission to compare the seismic suitability of different regions for nuclear power plant siting. Suitability, as defined in this comparison, reflects the difficulty encountered in determining the seismic character of a particular site within the zone, not the seismic risk itself. It should be noted, however, that regions of severe earthquake activity are generally characterized by complicated geology. Studies of geologic aspects, such as ground dynamics, in these areas are likewise complicated. Thus, delineations of seismic risk and seismic suitability are often quite similar. This is certainly the case in the western United States, as seen by comparing Figures 4.12 and 4.13.

4.5.3 Selection Conclusions

Ideally, a surrogate site for a DCNEC would lie in a Zone 1 area to minimize seismic considerations. However, the only Zone 1 regions in the western U.S. lie too far from the major electricity load centers to be considered for DCNEC siting. Since seismic investigation of sites within Zone 3 are impracticable, the four surrogate regions selected are within Zone 2. During the site-specific analysis stage, therefore, it is essential that geologic investigations be undertaken to determine the seismic characteristics of the surrogate site selected.

ZONE I: SUITABLE SITES CAN BE FOUND WITH LITTLE DIFFICULTY.
 ZONE II: DETAILED SITE SPECIFIC STUDIES WOULD BE
 REQUIRED TO DETERMINE SUITABILITY.
 ZONE III: COSTS AND TIME REQUIRED FOR INVESTIGATIONS MAKE
 IT IMPRACTICAL TO CONSIDER THIS ZONE FOR
 NUCLEAR POWER PLANT SITING

Figure 4.13 Seismic Suitability in the
 DCNEC Study Region

4.6 WATER RESOURCES

4.6.1 Water Requirements

Approximate cooling water flow rates required for operation of typical heat dissipation systems for a 1200 MWe light water reactor plant are summarized in Table 4.3. Also included in this table are estimates of the annual consumptive water requirements for a 1200 MWe light water reactor plant operated with either an evaporative cooling system or a dry cooling system. In comparing the water requirements of these two systems, the advantages of dry cooling at arid sites are obvious.

Nonetheless, some in-plant consumption of water occurs in a dry-cooled plant; this amounts to a continuous flow of 2-3 cfs in a 12-reactor DCNEC. In addition, water would be required during the construction phase. These requirements make it necessary to consider water resources, for even a small outflow can, in some instances, significantly deplete the water supply in arid regions of the western United States.

4.6.2 Water Supply Assessment in Surrogate Regions

4.6.2.1 Surface Water

Much of surrogate regions 1, 2 and 3 lie within the Westwide Study (Ref. 2) classification of "areas yielding little or no surface runoff and/or underlain with poor yielding ground-water aquifers." An exception to this is the Colorado River drainage within Region 3. Here, the water of the Colorado River is adequate to meet existing quantitative requirements and

TABLE 4.3
WATER REQUIREMENTS FOR
NUCLEAR POWER PLANTS

A. Approximate Cooling Water Flow Rates Required for 1200 MWe Power Plants

<u>Type of Cooling</u>	<u>Water Flow Rate</u>
Once-through	1250 cfs (561,000 gpm)
Evaporative tower	50 cfs (22,500 gpm) makeup 4-9 cfs (2700 gpm) blowdown
Dry tower	0

B. Consumptive Water Requirements for In-Plant Service and for Cooling Water to Dissipate Waste Heat From a 1200 MWe Light Water Reactor (based on 70% capacity factor) (Ref. 3)

<u>Type of Cooling</u>	<u>Water Required</u>
Evaporative tower	15,000 acre-feet/year (4.9×10^9 gallons/year)
Dry tower	150 acre feet/year (4.9×10^7 gallons/year)

those of the near future. For the long range, tradeoffs with irrigation development would probably be necessary to permit surface water to be used for energy development.

Region 4 (Sacramento) has a potential for additional development of surface water supplies, probably sufficient to support additional wet-cooled nuclear development. The feasibility will depend on the cost of developing and transporting surface supplies and on the pricing policies of distributing agencies. Several options in regard to surface water supplies exist in the Sacramento area as well. A potential exists for use of agricultural waste water or oil field waste water. One of the most promising potential sources of fresh water is reclamation of municipal and industrial waste water.

4.6.2.2 Ground Water

It would appear that in the arid surrogate regions, ground water has the greatest potential to supply the water required by a DCNEC. Major ground-water aquifers for all four DCNEC areas are shown in Figure 4.14. (Ref. 4) These yield more than 500 gpm to wells and possibly could provide adequate supplies for nuclear energy development. In selecting a particular surrogate site, more detailed information based on site specific investigations is needed to determine the capability of ground water to satisfy the DCNEC water requirements.

Figure 4.14 Major Ground-water Aquifers

4.7 ATMOSPHERIC EFFECTS

The concept of a dry-cooled nuclear energy center has been examined to identify potential effects of such a center on the atmosphere. Since there are no existing dry-cooled energy centers, first-hand data on their impact do not exist. Further, experience with dry cooling systems is limited to units more than an order of magnitude smaller than those needed for a single power reactor. It is necessary, therefore, to extrapolate existing data on the effects of single power plants and small (2-3) power plant clusters to obtain the desired estimates. Some additional insight into possible effects of DCNECs can be gained by drawing analogies with other phenomena which involve large heat releases, such as forest fires, large urban areas, and volcanoes. Rotty (Ref. 5), Koenig and Bhumralkar (Ref. 6), and Hanna and Gifford (Ref. 7) use both extrapolation and analogy. Realistically, the conclusions reached through these techniques should be viewed as speculation based on experience and physical insight.

A DCNEC may affect the atmosphere and atmospheric processes in several ways. The most significant of these are the addition of thermal energy and the perturbation of natural air flow; without them DCNECs would not be feasible.

The construction of an energy center, whether dry- or wet-cooled, has other atmospheric implications. The physical structures themselves represent a change in surface, thermal, and roughness characteristics which may cause local climatological modifications. However, the local nature and relatively small magnitude of these climatological modifications reduce them to second-order importance; they will not be considered further.

The construction of an energy center will result in changes in population density and land-use patterns which, in turn, will have an impact on the atmosphere. The indirect impact of an energy center on air quality may be as large as, or larger than, any of the direct effects. Indirect impacts are not examined in this cursory study, but warrant close consideration in future studies.

The following discussion is an attempt to qualitatively estimate the magnitude of the direct impacts of a DCNEC due to the air flow and the release of thermal energy. Where numerical values are given, comparisons between values and general trends are more significant than the actual numerical values.

4.7.1 Air and Land Requirements

Table 2.2 indicates that the air flow required for a dry cooling system for a single 1200 MWe nuclear power plant using an induced draft mechanical cooling tower is $2-3 \times 10^6$ cfs. This is about 5 times the flow required for wet cooling systems. The vertical velocity of air in wet and dry cooling towers is about the same. Thus, it is immediately evident that, for a given cooling requirement, the horizontal extent of an array of dry cooling towers must be about five times as large as an equivalent array of wet towers.

Individual cooling tower arrays must be separated to permit adequate air flow and limit recirculation of thermal plumes. The land requirements for dry cooling are discussed in section 2.3.4. In a four-unit cluster, the area required for dry cooling towers is assumed to be approximately three times the area required for cooling towers for four individual power plants. The ratio between the actual land area requirements and the physical dimensions of dry cooling towers is also

assumed to increase as the number of clusters increases. For an energy center consisting of three four-unit clusters, the minimum area required to permit adequate separation of cooling systems is assumed to be seven times the actual area of the cooling systems.

4.7.2 Wind Generation

These assumptions have been used, in conjunction with the estimated flow characteristics of a dry-cooling system for a single 1200 MWe plant, to estimate horizontal winds in the vicinity of dry cooling systems for four-unit clusters and a 12-unit energy center. The model used is necessarily simple and does not treat the complicated flow patterns which would occur in any real energy center.

In essence, the total vertical air flow is equal to the product of the number of units and the flow per unit. All units are assumed to be near the center of a circular area sufficiently large to permit adequate separation between cooling systems. The air flow through a cylindrical surface extending above the perimeter is then set equal to the vertical flow and the required radial velocity is computed. Table 4.4 gives the model parameters. The computed radial velocities are given in Table 4.5. It should be recognized that within the four-unit cluster and the energy center, radial velocities associated with single units and four-unit clusters also apply as appropriate.

In the model described above, it has been assumed that the naturally-occurring wind is calm. In reality, the existing wind will affect the airflow. In these cases the airflow will not be uniformly distributed, but rather it will be high in some areas and low in others. In addition, the atmospheric

TABLE 4.4
AIRFLOW MODEL PARAMETERS

	<u>1 Unit</u>	<u>4 Unit Cluster</u>	<u>3 Cluster Center</u>
Total Area (acres)	18.7	223	1560
Inflow Radius (ft)	510	1760	4650
Inflow Height (ft)	30	50	100
Airflow (cfs)	3×10^6	1.2×10^7	3.6×10^7
Vertical Velocity (mph)	34	34	34

TABLE 4.5
RADIAL VELOCITIES REQUIRED TO GIVE THE
NEEDED AIRFLOW FOR DRY-COOLING SYSTEMS (MPH)

	Radius (ft)		
	<u>510</u>	<u>1760</u>	<u>4650</u>
1 Cooling System	21	3.6	0.7
4 Unit Cluster		15	2.8
3 Cluster Center			8

stability will govern the depth of the inflow to some extent. As a result, the radial velocities computed are only qualitative estimates; comparisons between velocities are better indicators than the actual velocity estimates. It should also be noted that the radial velocity estimates provided for the clusters and the energy center tend to be maximum values because minimum areas have been used. If the units and clusters were space farther apart, the velocity estimates would be lower.

4.7.3 Plume Rise

The exhaust from the dry-cooling system will form a plume which will generally rise considerably above the top of the cooling towers. Briggs (Ref. 8) published a critical review of data and models related to plume rise. Using his recommended formula for rise due to momentum, the plume rise for a single representative cooling tower was estimated for three stabilities and three wind speeds. The results of this computation are shown in Table 4.6. It is evident that plume rise due to momentum will be significant, even in moderately stable atmospheric conditions with high wind speeds.

TABLE 4.6
MOMENTUM RISE FOR A DRY COOLING
TOWER PLUME (IN FEET)

<u>Stability</u>	<u>Wind Speed (mph)</u>		
	<u>2</u>	<u>10</u>	<u>20</u>
Neutral	13,000	2,600	1,300
Slightly Stable	1,600	900	700
Moderately Stable	1,200	700	600

In general, however, a second factor, buoyancy, contributes more to plume rise than momentum does. As the air passes through a typical dry cooling tower its temperature rises about 40°F. The resulting difference between the density of air in the plume and the ambient air density gives the plume significant buoyancy. Again using formulations of Briggs, the rise of a plume from a single dry cooling tower was estimated. The results are shown in Table 4.7. It can be seen, by comparing the entries in Tables 4.6 and 4.7, that buoyant plume rise is somewhat greater than momentum rise during stable conditions.

When several plumes are present in reasonably close proximity, the plumes will combine. Rise of the combined plumes will then be greater than the rise of the individual plumes. The plume rise enhancement due to merger can be estimated using a relationship given by Briggs. (Ref. 9) In this relationship the enhancement is directly proportional to the estimated individual plume rise and inversely proportional to the initial separation between plumes. Figure 4.15 gives the ratio of the combined to single plume rise for four power plant clusters and a three-cluster center. In estimating the multiple plume rise shown in Figure 4.15, the cooling systems

TABLE 4.7
BUOYANT RISE FOR A DRY COOLING
TOWER PLUME (IN FEET)

<u>Stability</u>	<u>Wind Speed (mph)</u>		
	<u>2</u>	<u>10</u>	<u>20</u>
Neutral	9,000	1,800	900
Slightly Stable	3,700	2,100	1,700
Moderately Stable	2,100	1,200	1,000

Figure 4.15 Comparison of Combined and Single Plume Rise

in the cluster were assumed to be centered at the corners of a square 1750 feet on a side and the centers of the clusters were assumed to be at the vertices of an equilateral triangle 5000 feet on a side. It is apparent that plume rise is enhanced more by the combination of plumes within a cluster than by combination of the cluster plumes.

The curves shown in Figure 4.15 are for the specific spacing described above. Figures 4.16 and 4.17 show the ratios of enhanced plume rise to single cooling system (single cluster) plume rise as a function of the appropriate separation divided by single system (cluster) plume rise. Both figures show that increasing the separation between cooling systems in a cluster or between clusters significantly reduces the enhancement of plume rise.

The plume rise estimates given in Tables 4.6 and 4.7 and in Figures 4.15 through 4.17 are all based on formulas developed from theory and calibrated with small plumes. When used for cooling tower plumes, these formulas are extrapolated well beyond their data base. Thus, estimates derived from them are necessarily suspect and must be treated with caution. It is more appropriate to examine trends and relative magnitudes than it is to accept the estimates themselves.

4.7.4 Plume Temperature Diffusion

As a final exercise in scaling the atmospheric perturbation caused by dry cooling towers, the decrease in the temperature excess at the center of the plume was modeled. The temperature excess was assumed to diffuse in a manner similar to a passive containment. This diffusion can be described by a Gaussian plume model (Ref. 10) in which the maximum temperature excess is at the axis of the plume. Close to the individual

Figure 4.16 Plume Rise Enhancement for a Four Reactor Cluster

Figure 4.17 Plume Rise Enhancement for a Three-Cluster
Dry Cooled Nuclear Energy Center

cooling systems, the temperature excess in each plume decreases independently of the other plumes. At intermediate distances the plumes from cooling systems within a cluster merge and diffuse at a slower rate than they had initially, alone. Finally, at larger distances the plumes from the clusters merge and the diffusion is slowed even more. Figure 4.18 shows the individual diffusion curves for temperature excess (relative to initial temperature excess) as a function of distance for single cooling systems, clusters, and a three-cluster energy center. Figure 4.18 again shows that combining four power plants into a single cluster causes a larger percentage of change than does combining three clusters into an energy center. Figure 4.18, like Tables 4.6 and 4.7 and the previous figures, is dependent upon the assumed separation between power plants and clusters. Increasing the spacing between power plants would cause the plumes to diffuse singularly for a greater distance prior to combining into a single cluster-plume. Increasing the spacing between clusters would similarly delay the merging of the cluster-plumes. In effect, increasing separation would cause the displacement of a curve vertically downward until it became superimposed upon the curve for the next smaller group. Further separation would not affect the temperature excess at the plume axis.

To estimate the actual decrease in temperature excess in the case described, the curves shown in Figure 4.18 must be combined into a composite curve, such as that shown in Figure 4.19. In this case the diffusion is assumed to proceed as in a neutral atmosphere; lower diffusion rates are unlikely because of the interaction between the temperature excess and turbulence which causes diffusion. Figure 4.19 indicates that the temperature excess decreases by a factor of about two in the first 0.6 mile, is an order of magnitude lower than the

Figure 4.18 Dissipation of Temperature Excess for Single Dry Cooling Systems, Four Power Plant Clusters, and a Three Cluster Center with Distance

Figure 4.19 Dissipation of Temperature Excess with Distance for a 12 Unit DCNEC

initial excess by six miles and is reduced by a factor of about 70 at 60 miles. In reality, the distances required to realize the reductions quoted are probably overestimated because minimum diffusion rates have been assumed and infrared radiation losses have been ignored.

4.7.5 Potential Impacts

With the qualitative estimates of the atmospheric perturbations which might be caused by dry cooling systems in a nuclear energy center as a background, it is appropriate to examine the potential impact that these perturbations might have on the atmosphere and atmospheric processes. The perturbations which appear most probable are the formation of a localized relatively high-speed wind field in the immediate vicinity of the cooling towers, the concentration of existing atmospheric vorticity, the formation of an "equivalent thermal hill", and the triggering of more severe atmospheric phenomena, such as thunderstorms.

The potential for formation of a relatively high-speed wind field in the vicinity of the cooling systems has been discussed. The vorticity concentration is related to high speed winds and to the horizontal convergence of the wind field required to provide the vertical flow rate needed in the dry cooling systems. Concentration of vorticity has been observed near forest fires and other large sources of energy. It is inferred for energy centers by analogy. Possible mechanisms for the generation or concentration of vorticity include wake vortices and conservation of angular momentum. It has been estimated (Ref. 9) that these mechanisms could result in formation of large dust devils. Considerable work is needed to provide

definitive criteria for predicting this phenomenon and to evaluate the implications of concentration of vorticity, if it does occur.

Under certain atmospheric conditions, the vertical air motions in the plumes from a DCNEC might act as a triggering mechanism for thunderstorms. The frequency of thunderstorms in an area can be used as an indicator of the potential significance of this perturbation. It is more likely to be significant in areas having a high natural occurrence rate. The impact would probably correspond to the typical behavior of natural thunderstorms. If natural thunderstorms are generally accompanied by lightning, heavy precipitation, and hail, then any thunderstorms triggered by an energy center could also be expected to have the same characteristics. Positive identification or elimination of this impact would be a significant statistical problem.

The heat island effect of cities is well documented and numerical modeling studies indicate that changes in the thermal characteristics of the earth's surface modify local climatology in much the same way as alternation of topographic features. Thus, it is appropriate to discuss the thermal impact of a DCNEC in terms of an "equivalent thermal hill". It is thought that a 12-unit energy center might create an equivalent thermal hill several thousand feet high and several miles in length. The impact of such a hill can best be estimated for any region by examining climatological differences between locations with variations of several thousand feet in terrain elevation. If there is significant increase in precipitation with increasing elevation, then similar increases in precipitation can be estimated as a result of airflow over the thermal hill. It is not possible to determine where this increase would occur, or

whether there would be an increase in total precipitation in a larger region surrounding the center. It is possible that any increase in precipitation might be a local feature resulting from the redistribution of precipitation (i.e., a change in spatial patterns) rather than an increase in the total.

As in many other postulated impacts of cooling systems, spacing between systems is important in estimating the effect of the thermal hill. If systems are placed sufficiently close together, air will be deflected around the center rather than lifted. If, on the other hand, they are separated by significant distances, the thermal hill effects will also be negligible. At the present time it is not possible to identify separations which either enhance or detract from formation of a thermal hill. Intuitively, however, it appears that single dry cooling towers and cooling towers in a tight cluster would be less likely to create a significant thermal hill than would the towers in a multiple-cluster energy center.

4.7.6 Summary of Atmospheric Effects

To summarize the above discussion, the grouping of power plants into clusters of four units each increases the potential for adverse atmospheric perturbations from energy releases. Possible perturbations include formation of persistent local high-speed winds, concentration of vorticity, and the triggering of thunderstorms. Although further combination of power plant clusters into an energy center will increase these effects relatively little, it can have another potentially significant effect: formation of an "equivalent thermal hill" which might modify existing precipitation patterns. Unfortunately, existing atmospheric models are inadequate to provide quantitative

or semiquantitative estimates of the effects of proposed power plant groupings which are needed to balance costs and benefits.

The potential impacts postulated above for dry cooling systems are analogous to those postulated for wet systems; the differences are primarily in magnitude. Both the airflow and sensible heat transfer are greater in dry cooling systems than in wet; as a result, in cases where similar impacts are postulated, the impacts may be assumed to be greater for dry systems. The impacts of wet cooling systems should be greater than those of dry only in cases which result directly from the release of moisture by the wet system.

In closing, a cautionary comment is in order. This discussion has been based entirely on the assumption that the power plants are located on level ground. The surrogate sites contain both level terrain and significant topographic features. The impacts of power plants in valleys or on hills may differ significantly from those on level terrain. However, treatment of these cases requires highly site-specific analysis.

4.7.7 Climatology of the Surrogate Regions

The climate of an area significantly affects the performance of cooling systems and their impact on the environment. To provide a common climatological basis for evaluating the performance and impact of dry cooling systems at the surrogate sites, a standard climatology for each region was prepared using data contained in the Climatic Atlas of the United States. (Ref. 11) These climatologies include monthly average temperatures, precipitation, sea-level pressure and wind speed (Tables 4.8 through 4.11). Each is intended to be representative of the region as a whole, not of particular locations

TABLE 4.8
 REPRESENTATIVE CLIMATOLOGY OF REGION 1,
 SOUTHEASTERN OREGON

Month	Average Daily Temp. (°F)	Average Precip. (inches)	Sea Level Pressure (inches)	Wind Speed (mph)
January	20	1.5	30.18	7
February	30	1.0	30.12	8
March	35	1.0	30.03	10
April	45	1.0	29.97	10
May	50	1.0	29.94	10
June	50	1.0	29.91	9
July	65	0.3	29.91	8
August	65	0.3	29.94	8
September	60	0.5	29.97	9
October	50	1.0	30.03	9
November	35	1.5	30.18	8
December	30	1.0	30.18	8

TABLE 4.9
REPRESENTATIVE CLIMATOLOGY OF REGION 2
EASTERN NEVADA

Month	Average Daily Temperature (°F)	Average Precipitation (inches)	Sea- Level Pressure (inches)	Wind Speed (mph)
January	20	1.0	30.15	8
February	30	0.8	30.09	8
March	35	0.8	30.00	10
April	45	0.8	29.94	11
May	50	0.8	29.88	9
June	60	0.5	29.85	9
July	70	0.5	29.88	8
August	70	0.5	29.91	8
September	60	0.5	29.94	8
October	50	0.8	30.00	8
November	35	0.8	30.15	8
December	30	0.8	30.15	8

TABLE 4.10
 REPRESENTATIVE CLIMATOLOGY OF REGION 3
 CALIFORNIA-ARIZONA BORDER

Month	Average Daily Temperature (°F)	Average Precipitation (inches)	Sea- Level Pressure (inches)	Wind Speed (mph)
January	50	0.5	30.06	7
February	55	0.3	30.03	8
March	60	0.2	29.94	8
April	70	0.1	29.88	9
May	75	0.1	29.83	9
June	85		29.77	10
July	90	0.5	29.77	10
August	90	0.5	29.83	9
September	85	0.5	29.80	7
October	75	0.5	29.88	7
November	60	0.3	30.03	7
December	50	0.5	30.06	6

TABLE 4.11
 REPRESENTATIVE CLIMATOLOGY OF REGION 4
 SACRAMENTO VALLEY

Month	Average Daily Temperature (°F)	Average Precipitation (inches)	Sea- Level Pressure (inches)	Wind Speed (mph)
January	45	2.0	30.15	8
February	50	3.0	30.09	8
March	55	3.0	30.06	10
April	60	1.5	30.00	9
May	65	1.0	29.94	9
June	70	0.5	29.91	9
July	75	0.2	29.91	8
August	75	0.2	29.88	7
September	70	0.3	29.98	7
October	60	0.8	30.00	6
November	50	1.5	30.19	6
December	45	2.0	30.12	7

within the area. Within each region, specific locations will be found in which the climate differs significantly from that indicated in the tables. Where an area includes both flat and mountainous terrain, the climatological data given are more applicable to the flat terrain.

In addition to the monthly average figures in Tables 4.8 through 4.11, cumulative frequency distributions for high temperatures were estimated for each of the regions. These distributions were used to prepare Figure 4.20. This figure shows the number of hours per year that the dry bulb temperature at each of the sites can be expected to equal or exceed a given value. The differences between regions are particularly evident in this figure. The number of hours in which the temperature exceeds 100°F is more than two orders of magnitude greater along the California-Arizona border than it is in either southeastern Oregon or eastern Nevada.

Figure 4.20 Number of Hours with Dry-bulb Temperature Exceeding a Given Value at Each Surrogate Site

4.8 ECOSYSTEMS

4.8.1 DCNEC Impacts on Existing Ecosystems

4.8.1.1 Construction

Since construction of a nuclear installation, whether for an energy center or for a dispersed site, involves the destruction of habitat, complete amelioration is not possible. However, the actual area involved in site construction is relatively small, perhaps a tenth of the controlled land area. Displaced animals and birds will have to move into territories already occupied. Some may not survive, but the proportion so affected will be relatively small.

Only if the site disrupts a fragile, small, or otherwise distinct habitat will the construction itself substantially affect plant or animal populations. However, the presence of many thousands of construction workers and their supporting populations will probably have a significant effect on wildlife in general and game animals in particular. The increase in hunting, fishing, and other outdoor recreation pursuits due to the population increase will produce perturbations of a much greater significance than the destruction of habitat by construction. The ultimate degree of this impact is not well known. Qualitatively, developing a community of thousands in an area where only a few hundred people had lived will increase pressures on wildlife of all types by several orders of magnitude.

Arid regions tend to have localized patches of nondesert environments in and near streams, lakes, springs, or mountain tops. These patches often support small populations of nondesert species that have been isolated for various intervals. The

small size of these populations, reflecting the sparse resources available, makes them very much more susceptible to extinction than the same species in larger numbers under similar impact.

4.8.1.2 Operation

Horizontal wind speed increases of several miles per hour probably will have little effect other than to wind-prune sensitive vegetation slightly and perhaps discourage some feeble flying animals, such as small butterflies or mosquitoes. These will be strictly local effects of little consequence.

Vertical air motion induced by the tower effluent could spawn convective storms and modify local precipitation.

In most ecosystems, moderate environmental perturbations often do not fundamentally alter the ecosystem. However, continuous or long-term modification of rainfall in arid regions will change the species presence and abundance. Vegetation probably will be the first significant biotic component to be altered. Considering the probable remoteness of the energy centers from surrounding wetter environments, dispersion via natural mechanisms of new species into the modified climate surrounding the reactors may be quite slow. This implies that the dispersion of weedy or undesirable species into the modified habitats may be relatively rapid, possibly expanding into new niches that have few constraints. The possibility that spectacular alterations in local communities will occur cannot be dismissed, but more likely there will be shifts in dominance between species already extant. (Ref. 12)

Sites with a high natural incidence of thunderstorms seem most likely to be subject to increased thunderstorm incidence that

might possibly be associated with waste heat discharges from nuclear power plants. In this respect, the eastern portion of the Arizona region seems most likely to respond with increased thunderstorm activity, since it already is subject to numerous summer storms. This region lies in a storm precipitation gradient (Ref. 13) so alternations due to an energy center will depend strongly upon the specific site selected.

Lightning accompanies convective storms. Assuming that condensation levels in atmospheres over arid regions are at relatively high elevations, most lightning might be cloud-to-cloud, but low-lying cumulus (such as would form in more moist air) could induce an increase in cloud-to-ground strikes. Should this occur, the incidence of wildfire probably would increase. Wildfires are, of course, a natural event in arid ecosystems; but after a century of fire suppression, some ecosystems would be devastated by a higher incidence of fires. The Sierra Nevada might fit this category, since fires have been suppressed in the forests for many years.

Some natural ecosystems have been adapted to more or less periodic fires. The giant sequoia of the Sierra is an example of a climax species that germinates following fire. On the other hand, some ecosystems are more sensitive to fire now than in the recent past, due to alteration in species composition. Eastern Oregon's sagebrush, for example, may succumb to increased fire incidence fueled by the dead stems of the ubiquitous cheatgrass, which did not exist in this region 150 years ago. This potential impact may be important beyond the immediate region of the energy center because an uncontrolled fire can burn many hundreds of square miles.

4.8.2 Rare or Endangered Species

The large areas under consideration for DCNEC siting make it inevitable that several species of marginally surviving animals will be affected. In general, two types of endangered or rare species must be considered: those restricted to specialized or local environments and large, conspicuous, and possibly persecuted inhabitants of wildlands. Many threatened amphibians, reptiles, and fishes are representative of the first type because the aquatic environments they require are rare in arid regions. Carnivorous mammals and birds are common representatives of the second type; the wilderness they inhabit is being domesticated.

The State of Oregon has identified 34 critical wildlife habitats in the southeastern part of the state for a variety of rare or endangered species. (Ref. 14) The particular sites chosen for the energy center can be selected to avoid disruption of these habitats by construction. Such detailed study is not available for the other regions, although California has investigated the generalized habitats or locations for rare or endangered species. (Ref. 15) Both the Sierra foothills and the Arizona border region contain habitats of these threatened species. Construction of the energy centers in the Nevada region probably would disrupt fewer known fragile or special habitats.

Table 4.12 lists rare or endangered species and notes the regions where they presently exist and sources of information. (Ref. 14 to 18) Careful investigations of the status of threatened species are available for California and Oregon but not for Nevada or Arizona.

TABLE 4.12
RARE OR ENDANGERED SPECIES IN THE
AREAS CONSIDERED FOR DCNEC SITING

<u>SPECIES</u>	<u>REGION</u>	<u>REFERENCE</u>
AMPHIBIANS		
Blunt-nosed Leopard Lizard	San Joaquin	15
Collared Lizard	Oregon	14,16
Leopard Lizard	Oregon	14,16
REPTILES		
Giant Garter Snake	San Joaquin	15
FISHES		
Colorado Squawfish	Arizona	15
Humpback Sucker	Arizona	15
Bonytail	Oregon	15
Lahontan Trout	Oregon	17
Catlow Valley Trout	Oregon	17
Warner Sucker	Oregon	17
Unnamed Pupfish	Oregon	17
Malheur Sculpin	Oregon	17
MAMMALS		
Sonoran Pronghorn	Arizona	16
Wolverine	San Joaquin	15
Richardson Ground Squirrel	Oregon	18
Kit Fox	Oregon	18
Canada Lynx	Oregon	18
Malheur Shrew	Oregon	18
California Bighorn	Oregon	18
BIRDS		
Bald Eagle	San Joaquin	15
Peregrine Falcon	San Joaquin, Oregon, Nevada	15,16
Yuma Clapper Rail	Arizona	15
California Black Rail	Arizona	15

4.8.3 Existing Ecosystems in the Surrogate Regions

The regions under consideration generally share a common aridity, but their rainfall patterns differ significantly. (Ref. 13) Consequently the vegetation, and to a somewhat lesser extent the animals, of the various regions differ both in appearance and periods of activity. The following paragraphs give a very brief overview of the general communities characteristic of the various areas.

4.8.3.1 Region 1: Eastern Oregon

The high plateau of eastern Oregon possesses a shrubby landscape dominated by big sagebrush and some greasewood, with an understory of cheatgrass. (Ref. 19) A century of grazing pressure has reduced the native perennial bunchgrass to remnants, replaced largely by the annual cheatgrass. (Ref. 20) Juniper woodlands appear on the higher elevations and a substantial portion of the region is internally drained, with shallow saline lakes in the lower elevation basins. Some characteristic animals include Prairie Rattler, Racer, Shorthorned Lizard, Mule Deer, Bobcat, Red Fox, Meadowlark, and Sagegrouse in this extensive arid zone. (Ref. 21)

4.8.3.2 Region 2: Eastern Nevada

This region of southeastern Nevada and western Utah is an extension of the Great Basin Desert. The vegetation is shrubby; sagebrush, shadscale, and winterfat are common, with greasewood in some saline basins. (Ref. 22,23) Junipers occur along some of the higher ridges. All of the vegetation is sparse, reflecting the slight rainfall and warm temperatures. Some of the plant species are adapted to summer growth patterns, in contrast

with the Oregon desert plants that typically are dormant or resting during the summer drought. In large part, this reflects the increase in incidence of thunderstorms from about a dozen a year in Oregon to about 30 a year in this region. (Ref. 13) Animals found here include many of those found in Oregon, such as Mule Deer, Bobcat, and Prairie Rattler. Others include Grey Fox, Western Toad, Desert Horned Lizard, Gambel's Quail, and Roadrunner. (Ref. 21)

4.8.3.3 Region 3: Southwestern Arizona

This region lies near the juncture of the Mojave Desert and the Sonoran Desert. (Ref. 23) The Sonoran region, with its wet summers, differs from deserts farther west in that it supports a very substantial increase in annual herbs. The Mojave landscape of Joshuatree, catclaw, and yucca contrasts with the striking Sonoran landscape of organpipe, saguaro, palo verde, and cresote bush. The region of interest here lies in the "tension zone" between these two landscapes; consequently, the species present are quite diverse in comparison with the other sites. Characteristic animal species include the Gila Woodpecker, Vermillion Flycatcher, Swainson's Hawk, Phainopepla, several rattlesnakes, Coachwhip, Red-spotted Toad, Desert Horned Lizard, Pronghorn, Bighorn Sheep, Ringtailed Cat, and Kit Fox. (Ref. 21)

4.8.3.4 Region 4: Central Valley and Foothills, Sierra Nevada, California

This region covers a wide range of habitats in the western foothills of the Sierra Nevada, from grasslands through oak woodlands to tall coniferous forests in the higher elevations of the mountains. (Ref. 24) The higher elevations in this region

are very much wetter than any other site under consideration, so the wide range of habitats probably means this region includes a wider range of species of plants and animals than the others. The very dry summers here have over the centuries produced a fire-adapted vegetation, from grasslands and chaparral to oak savanna and conifer forests. Thunderstorms are not especially common, but they can occur any time of year; summer storms are often dry. (Ref. 13) Typical species include Mule Deer, Black Bear, Grey Fox, Great Horned Lizard, Alligator Lizard, Prairie Rattler, Western Toad, Clark's Nutcracker, and California Quail. (Ref. 21)

4.9 SOCIOECONOMIC IMPACTS

Construction and operation of a DCNEC requires a work force of several thousand employees. In low-population areas a large percentage of these workers must migrate into the region. This can result in significant socioeconomic impacts on the existing communities. Information used in the following assessment of these impacts of a representative site came from previous work; no primary data was collected.

4.9.1 Construction and Operating Work Force Size and Timing

The available information sources pertain to wet-cooled nuclear centers, either once-through or evaporative cooling methods. This assessment assumes that the construction work force size and schedule for a DCNEC would be approximately the same as for a wet-cooled nuclear energy center.

As noted in Section 2.6 the reactor completion intervals are assumed to be annual. Table 4.13 is based on typical reactor construction schedules proposed for a hypothetical energy center at Camp Gruber, a former military reservation just east of Muskogee, Oklahoma. (Ref. 25) Adjustments were made in this schedule to include six additional reactors at the DCNEC. This results in a construction period of 16 years, rather than 10. The peak construction work force is reached in the fourth year and remains near 4600 until the twelfth year, when it begins to decline.

A single nuclear power plant requires an operating work force of 120 to 150. A reduction per unit is possible for additional plants at the same site. For the DCNEC analysis, an operating work force of 60 per unit was assumed based on the River Bend site projections (Ref. 26) which were adjusted proportionately

TABLE 4.13
POTENTIAL CONSTRUCTION FORCE FOR DRY-COOLED NUCLEAR ENERGY CENTERS

Time (Years)	Number of Construction Workers												Total Con- struction
	Plant No. 1	Plant No. 2	Plant No. 3	Plant No. 4	Plant No. 5	Plant No. 6	Plant No. 7	Plant No. 8	Plant No. 9	Plant No. 10	Plant No. 11	Plant No. 12	
0	0												0
0.5	80												80
1	300	0											300
1.5	640	80											720
2	990	300	0										1290
2.5	1390	640	80										2110
3	1530	990	300	0									2820
3.5	1540	1390	640	80									3650
4	1540	1530	990	300	0								4360
4.5	960	1540	1390	640	80								4610
5	220	1540	1530	990	300	0							4580
5.5	0	960	1540	1390	640	80							4610
6		220	1540	1530	990	300	0						4580
6.5		0	960	1540	1390	640	80						4610
7			220	1540	1530	990	300	0					4580
7.5			0	960	1540	1390	640	80					4610
8				220	1540	1530	990	300	0				4580
8.5				0	960	1540	1390	640	80				4610
9					220	1540	1530	990	300	0			4580
9.5					0	960	1540	1390	640	80			4610
10						220	1540	1530	990	300	0		4580
10.5						0	960	1540	1390	640	80		4610
11							220	1540	1530	990	300	0	4580
11.5							0	960	1540	1390	640	80	4610
12								220	1540	1530	990	300	4580
12.5								0	960	1540	1390	640	4530
13									220	1540	1530	990	4280
13.5									0	960	1540	1390	3890
14										220	1540	1530	3290
14.5										0	960	1540	2500
15											220	1540	1760
15.5											0	960	960
16												220	220
												0	0

from a 28-reactor center to a 12-reactor center. The operating personnel schedule (Table 4.14) is expected to be implemented one year prior to the beginning of operation of the first reactor. The operating employment level will increase annually thereafter to a peak of 720 employees when the center is in full operation.

The operating work force is minimal in size, compared to the construction work force. However, the initial operating employment occurs during the construction work force peak. Table 4.13 reflects operating and construction personnel combined. The peak work force is expected to reach 5120 employees 12 years after the start of construction.

Figure 4.21 shows how significantly the work force peak is affected by the reactor completion intervals. If the reactors are completed every six months, the potential work force peak would be 9350 during the sixth year of an 11-year construction period. In contrast, if the reactor completion interval is every two years, the peak work force would be 3130 in the twenty-fourth year of a 27-year construction period.

4.9.2 Secondary Employment

Determination of the ratio of secondary employment to primary employment involves classification of economic activities into basic and nonbasic industries. A basic economic activity produces goods and services locally but exports its production out of the region. The demand for products of the basic industry is assumed to be independent of intraregional developments. The basic industry supports secondary industries in direct relationship; this is referred to as the basic service ratio or employment multiplier. Any one firm or industry may produce

TABLE 4.14
PROJECTED OPERATING WORK FORCE AND TOTAL WORK FORCE
FOR A DRY-COOLED NUCLEAR ENERGY CENTER

Year	Plant #1	Plant #2	Plant #3	Plant #4	Plant #5	Plant #6	Plant #7	Plant #8	Plant #9	Plant #10	Plant #11	Plant #12	Total Operating Force	Total Work Force
1														300
2														1290
3														2820
4	60												60	4420
5	↓	60											120	4700
6	↓	↓	60										180	4760
7	↓	↓	↓	60									240	4820
8	↓	↓	↓	↓	60								300	4880
9	↓	↓	↓	↓	↓	60							360	4940
10	↓	↓	↓	↓	↓	↓	60						420	5000
11	↓	↓	↓	↓	↓	↓	↓	60					480	5060
12	↓	↓	↓	↓	↓	↓	↓	↓	60				540	5120
13	↓	↓	↓	↓	↓	↓	↓	↓	↓	60			600	4880
14	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	60		660	3950
15	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	60	720	2480
16	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	720	940

Figure 4.21 Construction and Operating Work Force for 6 Months, 1-Year and 2-Year Reactor Completion Intervals

for export to some extent. This extent of export production by an industry is often measured by its "location quotient," which measures the concentration of an industry in an area relative to the national average. (Ref. 27)

The value of the employment multiplier varies among industries, regions, and over time as the extent of production which is exported out of the region changes. (Ref. 27) An analysis conducted by Harvey revealed several factors that influence the variation in the employment multiplier. (Ref. 28) Initial significant conditions in the regions were: a) population size, b) growth rates of cities, c) female participation in the labor force, and d) the per capita income ratio of labor to nonlabor income. In the absence of a specific site, the results of the Harvey study could not be used to select a multiplier. Further work on this multiplier is planned.

Various values for employment multipliers have appeared in recent environmental reports. A multiplier of 2.5 was estimated for the Washington Public Power Supply Service reactors 1 and 4. (Ref. 27) In contrast, the Medocino Power Plant estimated a multiplier of 0.25 for secondary to primary employees and their dependents. (Ref. 29) The Camp Gruber nuclear energy center study utilized a multiplier of 2.0 because it assumed there would be a limited multiple expansion in the service sector due to the short duration of the construction period (10-years). (Ref. 25)

Following the Camp Gruber study, an employment multiplier of 2.0 was selected. The construction duration period for the DCNEC is six years longer, allowing more time for multiple expansion of service industries. However, a typical DCNEC

site is expected to be more isolated than Camp Gruber, so the two effects would be expected to balance. Using the multiplier of 2.0 total construction, operating, and secondary employment is expected to peak at 10,240 workers and stabilize at 1,440 workers.

4.9.3 Population

Unemployed workers in the area near the nuclear energy center will seek employment in construction or operation of the DCNEC or in those local service industries which will expand in response to the center. This local labor pool will reduce the number of workers, and hence, the total number of people moving into the community. This reduction in overall population growth would lessen all of the adverse socioeconomic effects of the center. However, the surrogate site is assumed to be a lightly populated area. Therefore, there will be little available unemployed labor, and a considerable influx of population into the area can be expected.

In order to determine the population influx which would result from employment increases, family sizes and sources of secondary workers were considered. National averages are 1.46 workers per family and an average of 3.3 persons per family. (Ref. 30) This results in a population multiplier of $\frac{3.3}{1.46}$ or 2.25, which can be applied to the total work force. Total area population is estimated to grow to 19,890 by the fourth year, to peak at 23,040, and to stabilize at 3,240, assuming that the electricity is exported out of the area so that new businesses are not attracted to the area by low-cost power. This population multiplier may be too high if there are more single people in the construction work force than in the national average; but data is not sufficient to assess that possibility at this time.

4.9.4 Private Business

National average wages for May 1975 were used to determine incomes for the construction and operating work force. Annual wages are assumed to be \$13,000 for the construction worker and \$12,250 for the operating employee. (Ref. 31) During the peak employment period total incomes of construction and operating workers would be 66.2 million dollars (1975 dollars).

Local business will experience increased sales as construction workers and operating personnel spend part of their incomes on products and supplies, and site contractors will purchase some materials and supplies locally. This portion of workers' wages spent for consumption is referred to as the propensity to consume. These increased sales of goods and services stimulate businessmen to expand facilities and staff. This increased staff was referred to previously as secondary employment and was estimated using an employment multiplier of two. Using this multiplier, it is estimated that the total incomes in the DCNEC area will peak at 132.3 million dollars and stabilize at 17.6 million dollars (1975 dollars).

4.9.5 Housing

The impact of DCNEC construction and operation on housing will depend on the supply of vacant housing and the influx of workers. Under the most adverse conditions in which little or no vacant housing exists, and assuming 0.9 households per worker, (Ref. 30) the additional peak demand could be 9,216 units. This represents a maximum value; depending on existing housing in the study area, this figure could be lower than under these adverse conditions.

A typical solution to the temporary housing problem is the use of mobile home parks and multiple housing units. It should be noted that poor planning of such developments and lack of zoning regulations could result in more adverse impacts for the community. Construction of new housing units will probably be limited because the additional housing demand is somewhat temporary. The operating and secondary service personnel will probably desire permanent single-unit housing. Therefore, it is anticipated that these personnel will be living in 1,296 single housing units. Some of these housing units may not be single family units; the extent of multiple units in this total depends on several factors, including the percentage of single workers in the construction work force.

4.9.6 Public Services and Facilities

The large influx of population resulting from construction and operation of a DCNEC can congest existing public services and facilities. Typically, education, transportation, fire and police protection, water and sewage facilities, and health services are seriously affected. The increased demand for such facilities and the existing amount of underutilized capacity must be considered to determine the quality and quantity of new services and facilities which will be needed.

A recent study estimated the development cost of a new community with a population of 33,000 to range from \$107,870,060 to \$164,617,000, depending on prior development of the area. These estimates include roads, sewers, public buildings, schools, and other services and facilities. The per capita cost ranges from \$3,269 to \$4,988. (Ref. 32) A more isolated area will have minimal existing public services and facilities and will probably incur greater expenses. Therefore, for this analyses it is estimated that a total capital investment of \$114,724,000 would be incurred for a new town of 23,000 people, the peak population. The actual extent of capacity expansion

in public facilities and services will depend on the length of the peak and the lifetime of the capital investment. The population will not stabilize at 23,000; rather, it will be near 20,000 for about 10 years. The community may tolerate congestion and degradation of services and facilities to a certain extent during the temporary peak.

The largest single expenditure of a local government is education. Construction of a DCNEC would add approximately 4,600 additional elementary students and 1,850 secondary students during the peak years of construction and 648 elementary and 259 secondary students after the center is in full operation. (Ref. 25) An existing school system in low-population areas would probably not be able to accommodate the additional students. Numerous methods are available for handling new students. These include construction of permanent facilities or installation of temporary facilities, such as mobile classrooms.

During construction, up to 5,120 workers will commute daily to the reactor sites. With heavier traffic load, additional employees and equipment will be required for street repair and maintenance and for construction of additional streets and roads. These activities may disrupt existing neighborhoods.

Water consumption and sewage production is of particular interest in arid regions. Assuming an average daily water consumption of 470 gallon/person with a peak of 1,200 gallons/person, water consumption could range from 10.8 to 27.6 million gallons/day for a peak population of 23,000, and ultimately from 1.5 to 3.8 million gallons/day for a population of 3,200. (Ref. 30) This represents an average annual water consumption of about 12,000 acre-feet for the peak population and about 1,700 acre-feet for the ultimate population. For comparison, a 12-unit DCNEC would require about 1800 acre-feet per year for in-plant uses (Table 4.3).

Assuming an average daily sewage generation of 120 gallons/person, the required sewage treatment capacity would be 2.8 million gallons/day for the peak population, and 0.4 million gallons/day for the ultimate population. A low-population community would not likely have excess capacity to cover the increase in water consumption and sewage treatment. Disruptive impacts may also result from new users outbidding existing users for the water.

4.9.7 Taxes

The construction and operation of a DCNEC will generate increased tax revenues and demand for public services. Unfortunately, the time at which the tax revenues are available and their distribution among local governments often do not match the times and locations of the increased demand for public services. (Ref. 33)

The property tax is typically the only source of revenue to the local government. Retail sales tax and income tax are usually primary revenue sources for the state government. Often, the utility will make tax payments from the beginning of plant construction. However, typical payments during construction are based on investment to date. Therefore, in the initial years of construction the property tax is minimal and does not fully cover the additional costs for public services and facilities. (Ref. 33) Using the construction schedule in Table 4.8, the property tax payment on full assessed value of the first reactor will not occur until the fifth year and property taxes will not be paid on the full assessed value of the center until the sixteenth year. If the tax base is located in one or two counties and the additional expenditure for public services occurs in counties that do not receive tax payments, these unrecompensed counties are more adversely impacted.

The effect of the DCNEC on the local tax base can be substantial when it is completed, especially in rural areas where the utility can generate a large percentage of the total county taxes. As noted in Section 2.2.1 the additional capital costs associated with dry cooling compared to evaporative cooling technology are expected to approximately balance the economics of scale in construction of a 12 reactor energy center as opposed to dispersed reactor siting. Thus the construction costs of a DCNEC composed of twelve 1200 MWe reactors is estimated to be \$7.2 billion in 1975 dollars. It is assumed that this would be the value of the DCNEC for tax purposes if the DCNEC had existed in 1975. This figure should be escalated to the year in which the DCNEC would be completed, when that date becomes known. Other estimates for the value of such an energy center range up to \$12 billion in 1975 dollars. (Ref. 34)

Property tax payments often vary among states and even among counties because of the difference in assessment and millage rates. Depending on the location, a DCNEC worth \$7.2 billion would generate annually \$148 million in taxes in San Bernardino County, and \$204 million in Sacramento County in California \$90 million in Clark County in Nevada, and about \$190 million in southeastern Oregon. (Ref. 35)

Mobile homes will probably be used extensively to supply the housing demand resulting from the construction phase of the DCNEC. This could broaden the tax base for the community if the mobile homes are taxed as real property. However, mobile homes are often taxed at a lower rate than permanent housing. They may even be taxed as motor vehicles, which would result in no revenue for the local government, as motor vehicle taxes go to the state government. (Ref. 33)

4.9.8 Population Density and Distribution

In a socioeconomic analysis of a DCNEC, the impacts involved are a function of population density and distribution in the surrounding area. These characteristics should be generally identified for the surrogate regions of interest.

Surrogate Regions 1 and 2 contain areas with population densities of less than 5 people per square mile. Region 3 encompasses an area with a population density ranging from less than 5 people per square mile in Arizona to between 50 and 100 people per square mile in California. The portion of Nevada included within the Region 3 boundary has a population density of from 25 to 50 people per square mile. Region 4 population density varies from 10 to 25 people per square mile in the eastern portion to over 250 near Sacramento.

The locations and relative sizes of population centers within these boundaries are shown in Figure 4.22. Also shown are the major concentrations of population in the seven far-western states which would likely constitute the load centers to be served by nuclear energy centers. The major urban load centers in the west (serving from 3 to 8 million people) are the Los Angeles and San Francisco metropolitan areas in California. Fairly large energy demands (to serve from 500,000 to 1,000,000 people) are also found in the Seattle-Tacoma area in Washington, the Portland metropolitan area in Oregon, the San Diego and Sacramento areas in California, and the Phoenix metropolitan region in Arizona. Of lesser significance (250,000 to 500,000 people) are the regions around Spokane, Washington, and Salt Lake City, Utah.

Figure 4.22 Population Centers

4.10 SITE SELECTION CONCLUSIONS

4.10.1 Basis For Region 2 Selection

Based on the evaluations of the four surrogate regions, Region 2 (the area containing a significant portion of eastern Nevada) was chosen as the most suitable for use in the DCNEC analysis. Regions 1, 3 and 4 were considered less desirable for the following reasons.

4.10.1.1 Southeastern Oregon/Southwestern Idaho Area

No rail transportation is available in this area. From existing railheads in Nevada and Idaho, additional overland transportation on the order of 100 to 200 miles would be required. The absence of transportation facilities makes this area far less desirable than regions with adequate transportation.

4.10.1.2 Lower Colorado River Area

The number of hours per year during which the dry-bulb temperature exceeds 100°F is approximately ten times greater in the Lower Colorado River area than in any of the other regions. Such high ambient temperatures impose an especially severe thermodynamic penalty on a DCNEC, which cannot reject heat at temperatures lower than the atmospheric dry-bulb temperature unless a supplementary cooling scheme is available.

4.10.1.3 Sacramento Valley Area

According to Energy Dilemma, a report published by the California Department of Water Resources in June 1973, the Sacramento Basin has the potential for additional development

of major surface water supplies. In addition, according to the report, the ground-water supplies underlying the Sacramento Valley are part of a more extensive ground-water basin with the largest usable storage capacity and the highest annual primary recharge in the state. Accordingly, even though alternate demands on the water resources are high in the Sacramento Valley and are likely to become higher in the future, the potential would exist for using wet cooling methods if an energy center were built in that area.

4.10.2 Basis For Galt Surrogate Site Selection

Having confirmed that the eastern Nevada area meets all of the criteria used in the coarse screening process, additional screening was performed to identify potential surrogate sites within the area. Five sites, shown in Figure 4.23, were chosen. The sites, which are identified by the names of communities within their boundaries, are as follows: 1) Galt, about 50 miles northeast of Las Vegas; 2) Panaca, to the north of Galt; 3) an area about 25 miles north of Ely; 4) Deeth, about midway between Elko and Wells; and 5) Shafter, about 25 miles east of Wells. Each of the sites is located at or near an existing rail line and has a ground-water supply that, based on preliminary analysis, will probably support operation of a DCNEC. Topography was also considered in potential surrogate site delineation, as areas of relatively flat terrain were included within each site.

Further analysis showed that the two sites in southern Nevada (Galt and Panaca) appeared to be the most suitable, based upon transportation needs. Long Beach Harbor and the connecting rail line could provide for the shipment of large components to these areas, but not to the sites further north. (Delivery

Figure 4.23 Potential Surrogate Sites for Analysis of a Dry-Cooled Nuclear Energy Center

of components to the northern sites would involve use of a long, circuitous railroad route from Oakland, California, or even longer overland routes from the east through Salt Lake City or Ogden, Utah.)

In comparing the Galt and Panaca surrogate sites, the Galt area (Figure 4.24) was determined to be preferable because transmission of electricity to the major load centers of southern California, Arizona, and Nevada would be less costly from this site. Also, its proximity to the city of Las Vegas could prove useful during the construction phase of a DCNEC.

Figure 4.24 Location of Surrogate Site for DCNEC Analysis

REFERENCES

Section 4

1. S. T. Algermissen. "Seismic Studies in the United States," p. 14-27, in 4th World Conf. Earthquake Eng. Proceedings: Asociation Chilena de Seismologia e Ingenieria Antisismica, Santiago, Chile, v. 1, 1969.
2. U.S. Department of the Interior. Critical Water Problems Facing the Eleven Western States: The Westwide Study, December 1974.
3. Assessment of Energy Parks vs. Dispersed Electric Power Generating Facilities, report submitted to the National Science Foundation by the General Electric Company, May 30, 1975.
4. Survey of Potentially High Yield Aquifers Within the Contiguous United States, report prepared by Fugro, Inc. for Battelle-Northwest, June 18, 1975.
5. R. M. Rotty. Waste Heat Disposal from Nuclear Power Plants. NOAA, Air Resources Laboratory, Silver Spring, MD, Technical Memorandum ERL-ARL-47, September 1974.
6. L. R. Koenig and C. M. Bhumralkar. On Possible Undesirable Atmospheric Effects of Heat Rejection from Large Electric Power Centers. Report No. R-1628-RC, Rand, Santa Monica, CA, December 1974.
7. S. R. Hanna and F. A. Gifford. "Meteorological Effects of Energy Dissipation at Large Power Parks," Bull. Am. Meteor. Soc. 56(10), 1975.
8. G. A. Briggs. Plume Rise, AEC Critical Review Series, TID-25075, 1969.
9. G. A. Briggs. "Plume Rise from Multiple Sources," in Cooling Tower Environment - 1974, S. R. Hanna and J. Pell, eds., ERDA Symposium Series Conf - 740302, 1975.
10. F. A. Gifford. "An Outline of Theories of Diffusion in the Lower Layers of the Atmosphere," in Meteorology and Atomic Energy - 1968, USAEC, TID-24190, 1968.
11. Climatic Atlas of the United States, Environmental Sciences and Service Administration, U.S. Department of Commerce, 1968.

12. C. F. Cooper. Ecological Effects of Weather Modification: A Problem Analysis. Univeristy of Michigan, School of Natural Resources, Ann Arbor, MI, 1969.
13. National Oceanic and Atmospheric Administration. Climates of the States, Vol. II: The Western States. Water Information Center, Inc., Manhasset Isle, Port Washington, NY, 1974.
14. M. H. Karr, and G. L. Wilfert. An Inventory and Evaluation of Areas of Environmental Concern in Oregon. Research report for the State of Oregon Executive Dept. and Natural Resource Agencies by Battelle-Northwest, Richland, WA, 1973.
15. At the Crossroads: A Report on California's Endangered and Rare Fish and Wildlife. Dept. of Fish and Game, Sacramento, CA, 1972.
16. Bureau of Sport Fisheries and Wildlife. Threatened Wildlife of the United States. U.S. Fish and Wildlife Service, Washington, DC, 1973.
17. Agricultural Experiment Station. Endangered Plants and Animals of Oregon: I. Fishes. Special Report 205, Oregon State University, Corvallis, 1966.
18. Agricultural Experiment Station. Endangered Plants and Animals of Oregon: IV. Mammals. Oregon State University, Corvallis, 1972.
19. J. F. Franklin and C. T. Dryness. Natural Vegetation of Oregon and Washington. Pacific Northwest Forest and Range Experiment Station Technical Report PNW-8, 1973.
20. A. Leopold. "Cheatgrass Takes Over," p. 154-518 in A Sand Country Almanac, Oxford University Press, 1949.
21. R. C. Stebbins. A Field Guide to Western Reptiles and Amphibians. Houghton Mifflin Co., Boston, MA, 1966.
R. T. Peterson, A Field Guide to Western Birds. Houghton Mifflin Co., Boston, MA, 1961.
W. H. Burt and R. P. Grossenheider. A Field Guide to the Mammals. Houghton Mifflin Co., Boston, MA, 1964.
R. C. Stebbins. Amphibians and Reptiles of Western North America. McGraw-Hill Book Co., NY, 1964.
22. A. Wallace and E. M. Romney. Radioecology and Ecophysiology of Desert Plants at the Nevada Test Site. National Technical Information Service, U.S. Dept. of Commerce, Springfield, VA, 1972.

23. C. H. Lowe. Arizona's Natural Environment. University of Arizona Press, Tucson, 1964.
24. P. A. Munz, and D. D. Keck. A California Flora. University of California Press, Berkeley, CA, 1963.
25. J. R. Young and K. E. Yandon. The Social and Economic Impacts of a Camp Gruber Energy Center, June 1975.
26. "Construction City Study for a Nuclear Power Center." Preliminary draft, United Engineers and Constructors, Inc., 1974.
27. Socioeconomic Study: Washington Public Power Supply System Nuclear Projects 1 and 4, Woodward-Clyde Consultants, April 1975.
28. A. Harvey. "Spatial Variation of Export Employment Multipliers: A Cross-Sectional Analysis." Land Economics, November 1973.
29. E. Peele. Social Impacts of A Remote Coastal Nuclear Power Plant, A Case Study of the Mendocino Proposal. June 1974.
30. G. L. Wilfert, K. E. Yandon and J. R. Young. "Economic Impact of A Hanford Enrichment Complex." September 1973.
31. U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings, Vol. 21, No. 12, U.S. Government Printing Office, Washington, DC, June 1975.
32. Real Estate Research Corporation for CEQ, HUD and EPA, The Costs of Sprawl, USGPO, April 1974.
33. Evaluation of Power Facilities, A Reviewer's Handbook, Berkshire County Regional Planning Commission, April 1974.
34. Nuclear Energy Center Site Survey - 1975, Report No. NUREG-0001, Part II, Chapter 9, U.S. Nuclear Regulatory Commission, Washington, DC, January 1976.
35. U.S. Bureau of Census, 1972 Census of Governments: Volume 2, Taxable Property Values and Assessment--Sales Price Ratio, Part 2, Assessment--Sales Price Ratios and Tax Rates, Government Printing Office, Washington, DC, October 1973.

5.0 PRELIMINARY ANALYSIS OF THE SURROGATE SITE

5.1 SITE DESCRIPTION

5.1.1 Location

The Galt surrogate site is in the northern part of the Mojave Desert, approximately 50 miles northeast of Las Vegas. The site lies generally between $114^{\circ} 15'$ and $114^{\circ} 45'$ longitude and is bisected laterally by the 37th parallel. Its boundary is completely within the State of Nevada, although its eastern edge is only about 10 miles from the Utah border.

The main body of the Galt site is the Lower Meadow Valley between the Mormon Mountains on the east and the Meadow Valley Range on the west (Figure 5.1). In addition, the site extends into the Tule Desert on the northeast and the Mormon Mesa on the southeast and contains a portion of Kane Valley on the western side of the Meadow Valley Mountains.

5.1.2 Natural Features

The most notable feature of this area is the Meadow Valley Wash, which runs through the center of the site in a general north-to-south direction. Runoff from the Lower Meadow Valley, as well as from valleys to the north, drain into this wash. At the southern end of the surrogate site the Wash intersects the Muddy River, which runs adjacent to the southwestern site boundary.

The climate of this area is generally hot and extremely dry. As a result, the site is relatively barren of groundcover, with only desert brush typical of Southwestern deserts flourishing.

Figure 5.1 Topography of the Galt DCNEC Surrogate Site

In addition, certain areas along the course of the Meadow Valley Wash support more abundant and diversified growth.

The terrain of the Galt area is irregular due to erosion by the Meadow Valley Wash and runoff from the surrounding mountains. The lowest elevation, just less than 2000 feet above sea level, occurs at the southern tip of the surrogate site, with the adjacent mountains rising above 7000 feet only 15 miles away. However, extremely flat areas lie on the Mormon Mesa section, in the Tule Desert, within the Kane Valley, and north of the mouth of Meadow Valley Wash. Also, the foothills leading up to the Mormon and Meadow Valley Mountains have relatively gentle slopes in some areas.

5.1.3 Human Activity

The area within the surrogate site is characterized by extremely sparse human activity. The several stops along the railroad line (Farrier, Rox, Hoya, Galt, etc.) are labeled metal sheds next to the tracks, rather than actual communities. Only a few scattered dwellings lie within the entire site, housing an estimated maximum of 20 people. There is no industrial activity and only a limited amount of grazing and farming along the Wash.

5.2 TRANSPORTATION

5.2.1 Major Components

5.2.1.1 Shipment to Site

A major factor in the Galt, Nevada area's selection as a surrogate site is its accessibility to transportation routes. Long Beach Harbor is a convenient off-loading point for the barged nuclear steam supply components and a major rail access route runs directly from Long Beach to the Galt area. However, due to the size of the components and the 420-mile distance, the usefulness of the rail line as a link between the barge facilities and the inland site must be examined.

Southern California Edison, in constructing a nuclear power plant near Vidal, California, plans to use a good portion of this route to transport nuclear steam supply components. They have studied the Atchison, Topeka, and Santa Fe rail line from Long Beach Harbor to Vidal in great detail and concluded that it can accommodate the bulky components with only minor alterations to the existing railroad structures (Figure 5.2). A bridge at Victorville, California, must be reinforced to support the weight and a signal must be moved at Barstow, California, to accommodate the wide load. Beyond Barstow, in the desert region, no further modifications are necessary.

For shipping similar components to the Galt site, it has been shown that the rail line out of Long Beach Harbor can definitely be used as far as Gale, California, a distance of about 170 miles. At Gale, a Union Pacific line forks northeast towards Las Vegas, with the approved AT&SF route to the Vidal

Figure 5.2 Steam Generator Shipment Route From Long Beach Harbor to Site

site continuing southeasterly. The terrain encountered on these routes is similar and a preliminary assessment of the grade and curvature of the Union Pacific line indicates that it too can accommodate the bulky components. However, a detailed study of this rail line from Gale, California, to the Galt site must be made to determine the validity of this preliminary conclusion. Areas of particular concern will be the Devil's Playground region near Kelso, California, where a summit is encountered, and the City of Las Vegas, where narrow rights-of-way may pose a problem.

5.2.1.2 Internal Transport

Transporting the components within the site itself is another important consideration. The Galt area, although classified as a desert region, is not a flat wasteland. Flat areas suitable for power plant siting do indeed exist within the surrogate area but numerous bluffs, gorges, mountains, and ravines have been carved out by geologic and hydrologic processes. Such features are formidable obstacles when transporting items weighing several hundred tons. Therefore, the site must be analyzed to determine internal transport limitations. Preliminary studies have shown where such limitations might arise.

The westernmost section of the surrogate site is a large, flat area called Kane Valley. The Meadow Valley Mountains run along the eastern edge of the valley and separate it from the railroad line. A pass bisecting the mountain range provides access to Kane Valley from the east. However, from actual observations of the area, it appears that the gradient over the pass may exceed the safety limit of the special vehicles used to transport the heavy components from the rail line.

The second area of possible internal transport limitations is the northeastern section of the surrogate site. This region, the Tule Desert, is extremely flat and may prove suitable for power plant siting. However, the Union Pacific rail line in the northern half of the surrogate site becomes extremely curvy as it winds along the narrow gorge of the Meadow Valley Wash. Due to the 225-foot radius-of-curvature restriction (Section 4.2.1), the transporting of the nuclear steam supply components along this stretch of line to reach the northerly flat areas may prove infeasible.

In at least these two places, further study is needed to determine the extent of internal transport limitations. In addition, internal transport within the surrogate site is complicated by the fact that the rail line follows the course of the Meadow Valley Wash. Since the Wash is the low point of the valley, transport of the components from the railroad to any other point will involve overcoming an upward slope. In general, due to the down-cutting action of the Wash, this climb is quite steep. The applicability of special tracked and rubber-tired vehicles to overcome these grades must be determined and optimum routes leading from the main rail line must be identified.

5.2.2 Labor Force

Several thousand workers will be involved in the construction of a DCNEC. These people must commute between the Galt site and their homes. Fortunately, commuter transportation links in the area are relatively well-developed, considering the remoteness of the region.

5.2.2.1 Highway Commuting

Interstate Highway 15 is the main road running north from Las Vegas. Starting at Glendale, about 50 miles northeast of Las Vegas, it lies adjacent to the southeastern boundary of the surrogate site. West of Glendale, State Highway 1 originates from the freeway and runs along the southwestern site boundary. This two-lane paved road passes through the town of Moapa about 5 miles from the freeway. At Moapa, Lower Meadow Valley Road begins and runs north, adjacent to the railroad line, through the surrogate site. This dirt and gravel road is in good repair for about the first ten miles but just north of Farrier it becomes rocky, twisting, and rutted. This section of the road would need to be greatly improved to accommodate commuter traffic.

5.2.2.2 Fixed-Rail Commuting

The Union Pacific Railroad runs through Las Vegas directly to Moapa and through the center of the surrogate site. It is in good condition as it is a main line serving the Southwest. The potential use of this rail line for daily commuting to the surrogate site is great. Perhaps by the period of theoretical construction, about 1990-2000, the character of commuter traffic will have changed due to economic and energy constraints. An existing rail line may prove to be an extremely useful substitute for individual commuter automobiles, particularly considering the distances involved in the Galt site analysis. A high-speed nonstop train from Las Vegas to the site could be a convenient and economical commuter tool. Feeder bus lines and biking facilities, which are well-suited to the flat, dry conditions of Las Vegas, could be

developed leading to the train station. Small electric carts powered from the DCNEC itself could perhaps be used to transport the workers to the train boarding location. With a bit of foresight and planning, a commuter network of conventional transport systems could be developed for the Galt site which would be independent of an unpredictable gasoline supply.

5.2.3 Equipment and Materials

As described in the previous section, the existing transportation system serving the Galt site is quite good. The highway network bordering the site and the Union Pacific rail line provide adequate access on which to ship construction equipment and materials. Within the site, however, improvements are needed to accommodate supply trucks and other overland vehicles. To provide access for these vehicles, the dirt and gravel road running north from Moapa would need improvement, particularly in the area above Farrier. Further study may even show that the existing right-of-way along Meadow Valley Wash should be moved to optimize internal transport. New roads would also be needed to connect construction sites with the rail line.

5.3 TRANSMISSION

The transmission aspects of the Galt site discussed in this section illustrate the effects of distance and major land features on choice of transmission methods and the estimated costs of the resulting systems. The concepts described are based on minimum data and analysis and are intended only to identify major considerations and the general magnitude of costs. This study encompasses a time period from 1985-2000, during which DCNECs and their associated transmission systems might be expected to develop. A comprehensive study, including consideration of integration with other facilities, load flow, and reactive and stability analyses, would be required to generate firm information on the transmission requirements of a DCNEC at the Galt (or any other) site.

5.3.1 Load Center Servicing

A DCNEC at the Galt surrogate site could conveniently serve load growth in the Los Angeles, San Bernardino, San Diego, Las Vegas, Ventura, Brawley, Phoenix, Tucson and Yuma areas. In formulating a transmission concept it has been assumed that the DCNEC would supply load growth at these centers in proportion to the load growth forecasts in Table 5.1.

A comprehensive study may indicate that it would be more economical for a DCNEC at Galt to supply a greater percentage of its output to the Los Angeles area, with load growth in the Phoenix area being supplied by Utah coal-fired plants. This could result in a lower overall average power transmission distance. Also, consideration could be given to serving loads in Nevada and Utah, as well as long distance DC transmission to the San Francisco area.

TABLE 5.1
LOAD GROWTH TO BE
SUPPLIED BY DCNEC

<u>Load Center</u>	<u>Percent of DCNEC Capacity Allocated</u>
Los Angeles including San Bernardino and Ventura	69
San Diego	8
Phoenix including Tucson	17
Las Vegas	4
Yuma	2

5.3.2 Transmission Line Network

The 500 kV AC transmission line overlay shown in Figure 5.3 would meet the requirements of the assumed load distribution outlined above.

Reliability requirements would be met, in that alternate paths would be available for power flow to the Los Angeles and Phoenix areas in the event of loss of a double circuit line, and support through the utility transmission systems would be available to the three smaller centers in the event of loss of the DCNEC line.

Future analysis of the relationship with then-existing 500 kV lines might indicate that one or both of the DCNEC lines to Phoenix should be replaced by a line or lines from the DCNEC to the existing 500 kV system near Hoover Dam and a new line segment from the vicinity of the Mohave plant to Phoenix, with the power flow from Hoover to Mohave being carried over existing lines. Since prior normal power flow over that line would be westward, a superimposed eastward flow would tend to unload it or to reverse the flow, with a

Figure 5.3 Conceptual Transmission System for DCNEC at Galt Surrogate Site 500 kV AC Lines

consequent more efficient use of the system and lower system losses. This illustrates the possibility for beneficial power-flow displacement.

5.3.3 Availability of Right-of-Way

Obtaining right-of-way in the triangle formed by Las Vegas, Tucson, and Los Angeles poses many problems:

- Much of the land in Nevada (87%), Arizona (85%), and southern California is publicly owned and dedicated to national forests, parks, Indian reservations, testing grounds, military reservations and the like.
- Several major geographical features block routing of transmission lines. Among these are Lake Mead, the Grand Canyon, the Lower Colorado River, and part of the High Sierra-Nevada Mountain Range.
- There are two points of extreme congestion through which many of the transmission lines from the Galt site would seek to pass:
 - the Henderson corridor, a 10 to 30 mile-long stretch between Las Vegas and the Lake Mead recreational area, and
 - the access points to the city of Los Angeles through El Cajon Pass and along Interstate 10.
- The climate of public and governmental opinion is strongly slanted toward protection of the environment. Utilities are being subjected to strong pressures to take all available measures for minimizing the environmental impact of transmission lines.

Furthermore, the possibilities for replacing low capacity lines in existing rights-of-way with high capacity lines may be limited in some cases by lack of available alternate routes for power transmission during the process of replacement.

Many of these problems would apply to transmission from a DCNEC or from new dispersed plants throughout the region. The Henderson corridor problem is unique to sites in the area north of Las Vegas, of which the Galt site is one. Lines to the south from the Galt site would have to pass through that area. Routes to the west are blocked by the Desert National Wildlife Range and those to the east by Lake Mead. Routes to the north that remain clear of Nevada Proving Grounds and the Las Vegas Bombing Range could take the lines as far north as Tonapah and would be very costly.

It has been reported that if the Intermountain Power Project and its transmission lines materialize, the available space in the Henderson corridor will be completely occupied. In that event the options would be to:

1. obtain permission to pass through the southeast corner of the Desert National Wildlife Range;
2. pass north of that range to its western boundary and get permission to traverse the Nevada Proving Grounds over routes in which the lines would not be adversely affected by tests; and
3. provide for 500 kV underground transmission in the Henderson corridor for a distance of 15 to 20 miles.

Although Figures 5.3 does not indicate these possible routings, their relative costs have been estimated, as follows:

	<u>Annual Differential Cost \$ Millions/Year</u>
Overhead lines through the southeast corner of the Wildlife Range	Base
Underground through the corridor	+ 88
Overhead through the Proving Grounds	+ 75
Overhead via Tonopah for L.A. loads, direct with UG link for others	+ 130

Since obtaining permission to exercise options 1 or 3 is highly conjectural, option 2 has been used in the estimates that follow. The possibility still remains that one or two overhead line positions through the corridor may be obtainable, but for purposes of this study all DCNEC lines through the Henderson corridor are assumed to be underground.

Although right-of-way space will be tight at El Cajon Pass, the indications are that overhead construction can be accommodated. Whether or not the relatively high towers of double circuit 500 kV overhead lines would be found acceptable in the approaches to Los Angeles is uncertain, but for purposes of this report it is assumed that they would be. Therefore, the only bulk transmission underground included in the estimate is that of the Henderson corridor. It is necessary to assume that a way will be found to overcome the other obstacles to transmission lines construction mentioned above, at unit costs that are acceptable.

Transmission plans required to implement the concept illustrated in Figure 5.3, using underground cables through the Henderson corridor, would consist of:

	<u>Miles</u>
Double circuit, high capacity 500 kV lines	850
Single circuit, high capacity 500 kV lines	1100
(together with terminal switching apparatus, series compensation, and other auxiliary apparatus)	
Underground high capacity 500 kV cable	150

5.3.4 Economic Summary

5.3.4.1 Capital Investment

Included in the estimate of capital investment are transmission lines, switching terminals, and series compensation. The estimate is derived from the application of unit costs being experienced in the industry, in 1975 dollars, to system requirements in terms of capacity and distance. No consideration has been given to local conditions as they may affect investment costs, other than in the section assumed to be underground. With these qualifications the estimate of capital investment in the Galt DCNEC transmission system, including interest during construction, is \$1,930 million.

5.3.4.2 Losses

The approximate losses have been computed for the transmission system with each nuclear complex fully developed and loaded.

The unit value of power losses in 2000 is estimated to be \$67 per kV-yr plus 6.3 mills per kW-hr. (Some of the California utilities value energy at its cost in oil burning plants in their studies of alternate ways of augmenting system transmission capacity. However, as nuclear capacity on a system increases, there should be opportunity to supply losses over a large part of the load cycle from the lower-cost nuclear energy sources while retaining the value of existing oil-fired plants for peaking purposes. The value of energy used in the study avoids analysis of interconnected systems by taking the option of balancing added transmission losses by added capacity in the DCNEC.)

Under the assumptions used in this study, the value of annual losses in the transmission system would be \$50 million per year.

5.3.4.3 Annual and Unit Cost

Under private ownership the general magnitude of bulk transmission cost for the concept described would be:

	<u>\$ Million per Year</u> (1975 dollars)
Annual fixed charges for transmission plant and operating and maintenance costs	330
Annual losses	<u>50</u>
Total	380

The average cost of transmission per kilowatt of DCNEC capacity would be \$26.30 per kW-yr, or 4.0 mills per kW-hr at 75% plant capacity factor. Computation of year-by-year costs, loads and losses would give a more rigorous measure of economic merit of transmission from a DCNEC. Unit cost of transmission would be greater than the 4.0 mills per kW-hr shown above in the early portion of the 1985-2000 period when the amount of power being transmitted would be relatively low and the initial lines required for reliability would be partially loaded.

5.3.5 Summary

Transmission requirements for a DCNEC depend on load locations, the status of the existing transmission system in the utility plans for transmission additions, and the availability of right-of-way for transmission lines. In this preliminary assessment only the load locations and guideline corridors have been considered. A bottleneck for lines running south from the Galt surrogate site exists in the Henderson corridor. Alternate routes were studied and it was concluded that for purposes of this study a 17-mile section of underground cable would be required in each of the circuits from a Galt DCNEC. This underground section would increase the Galt DCNEC transmission costs by about 30 percent.

A DCNEC at the Galt surrogate site would serve load growth in southern California and Arizona. These loads would use 75% and 25% of the DCNEC output, respectively. The system in that case would be at 500 kV AC, a voltage compatible with utility usage and plans in that region. The lines would have an average length of about 340 miles.

Bulk transmission cost from the Galt site is estimated as:

Capital investment	\$1930 million
Transmission losses	3.0%
Annual costs, including losses	\$380 million/year
Transmission cost/unit of energy generated	4.0 mills/kW-hr

5.3.6 Recommended Future Work

To obtain a more detailed and hence more dependable assessment of transmission problems and costs for a Galt surrogate site, additional work is needed. With the cooperation of the Western Systems Coordinating Council, the representative body of the utilities operating in that area, the following studies could be conducted:

- integration of the proposed DCNEC transmission system with the system to be in place by 1985;
- load flow, steady-state and transient stability, and electrical characteristics of dry-cooled generator systems;
- short circuit studies and operating modes to keep within anticipated allowable limits;
- system design, as modified by the results of the above studies, and time-phasing of additions;
- possible transmission line routes, costs of underground construction in the Henderson corridor (the scope of this study permitted only a rough approximation of these costs), and availability of alternate right-of-way for overhead lines; and
- reliability aspects of modified system design.

5.4 LAND USE CONSIDERATIONS

5.4.1 Nevada State Policy

The Nevada Public Service Commission (PSC) has exclusive jurisdiction in granting permits for the construction and operation of public utility facilities in the state. (Ref. 1) In regulating a public utility, such as a DCNEC, the PSC has two primary control devices, as described below. The PSC has sometimes issued both permits simultaneously, using a single application and hearing process.

The first is the Certificate of Public Convenience and Necessity, which must be issued before construction can begin (Ref. 2) These certificates are generally issued after public hearings and are primarily concerned with defining the extent, terms, and conditions of utility services. Such certificates are the most common form of state regulation nation-wide.

The second utility control device available to the Nevada PSC is the Utility Environmental Protection Act (UEPA) passed in 1973. (Ref. 3) This act regulates the granting of construction permits for any utility facilities that might have adverse environmental impact. The basic requirements of the UEPA are defined in NRS 704.890:

- "1. The commission shall render a decision upon the record either granting or denying the application as filed, or granting it upon such terms, conditions or modifications of the construction, operation or maintenance of the utility facility as the commission may deem appropriate. The commission may not grant a permit for the construction, operation and maintenance of a utility facility, either as proposed or as modified by the commission, unless it finds and determines:
 - (a) The basis for the need of the facility;
 - (b) The nature of the probable environmental impact;

- (c) That the facility represents the minimum adverse environmental impact, considering the state of available technology and the nature and economics of the various alternatives, and other pertinent considerations;
- (d) That the location of the facility as proposed conforms to applicable state and local laws and regulations issued thereunder; and
- (e) That the facility will serve the public interest."

The UEPA construction permit also requires specific consideration of intended exports of power from Nevada. The Public Service Commission may place a condition on a permit that the utility provide power for needs within the state, to the extent that power is produced using Nevada resources. (Ref. 4) Regardless of the source of DCNEC fuel, it is at least arguable that use of Nevada air or water for cooling may trigger this provision and therefore add to the scope of the Nevada Public Service Commission's control over any DCNEC.

The PSC controls rates for power sold in-state and the maintenance, use, and operation of transmission lines (although this latter control is shared with federal authorities). (Ref. 51, 52) Federal regulations control the possession and use of radioactive substances within the state, although the Nevada State Board of Health is designated as the State Radiation Control Agency. (Ref. 53, 54)

5.4.2 Conflicting Land Use

As noted in the general site description (Section 5.1), existing land utilization within the surrogate site is extremely limited. Although more than 90% of the area is administered by the Bureau of Land Management for grazing, only a small fraction is suitable pastureland for livestock. Crops are equally scarce, with just a handful of irrigated vegetable gardens being tended along the Meadow Valley Wash. Only

isolated parcels of land along Meadow Valley Wash are privately owned (Figure 5.4). No land within the area is designated as a preservation area or government reservation. Therefore, in the Galt area the problems associated with competing land uses at a DCNEC surrogate site are minimal. One complication might arise, however, in that the area involved is currently zoned as open space. Constructing a DCNEC would therefore require a conditional use permit or a variance under the provisions of the county zoning ordinances.

Consideration must also be given to adjacent land and its uses that may conflict with the presence of a nearby DCNEC. Effort has been made to identify all areas of designated land use within approximately a 100-mile radius of the Galt site. However, work remains to determine the significance of this proximity in relationship to DCNEC impacts.

5.4.2.1 Proximity to Potentially Hazardous Areas

Several federal military reserves are within 60 to 100 miles from the Galt DCNEC area (Figure 5.5). These include Nellis Air Force Base, Indian Springs Air Field, Nellis Air Force Range, and Nevada Test Site.

In order to evaluate the hazard potential, supplemental information is needed to identify:

- the nature and extent of activities at each facility;
- the nature and handling practices of any hazardous materials;
- potentials for accidents and incidents and possible magnitudes of such mishaps; and
- flight paths and patterns in use.

Figure 5.4 Land Ownership of Galt Site

Figure 5.5 Federal Military Reserves

5.4.2.2 National Forests

The nearest national forest (Dixie NF) is located in Utah, about 20 miles northeast of the DCNEC area. Portions of the Toiyabe and Humbolt National Forests in Nevada and the Kaibab National Forest in Arizona lie within 70 miles (Figure 5.6).

5.4.2.3 Parks and Preservation Areas

The closest national areas, located from 10 to 20 miles away, are the Pahrnagat National wildlife Refuge, Desert National Wildlife Range, and Lake Mead National Recreation Area (Figure 5.7).

Nearby Nevada State Parks include:

- Beaver Dam, 20 miles northeast
- Cathedral Gorge, 40 miles north
- Valley of Fire, 15 miles south

5.4.2.4 Indian Reservations

Located five miles from the southern boundary of the surrogate site is the Moapa River Indian Reservation. Also within fairly close proximity (about 60 miles) is the Las Vegas Indian Reservation (Figure 5.8). Supplemental information is needed to identify the population of the reservations and the nature and extent of developments, if any.

5.4.2.5 Registered Historical Sites

A number of historic sites are found within 30 miles from the surrogate site boundary. These include:

Figure 5.6 National Forests

Figure 5.7 National Preservation Areas

Figure 5.8 Indian Reservations

- Blank Canyon Petroglyphs, in Pahranaagat National Wildlife Refuge
- Caliente Railroad Depot, in Caliente
- Corn Creek Campsite, in Desert National Wildlife Range (DNWR)
- Hidden Forest Cabin, north of Las Vegas on Hidden Forest Road
- Blacksmith Shop, DNWR
- Mesquite House, DNWR
- Mormon Well Corral, near Las Vegas
- Sheep Mountain Range Archeological District, northwest of Las Vegas

5.5 GEOTECHNICAL CHARACTERISTICS

Figure 5.9 is a map showing the approximate outline of the surrogate site superimposed on a portion of a preliminary geologic map of Nevada. (Ref. 5) The map, while not a final version, does show the primary features of the land surface in the site area--elongated mountain ranges of Tertiary and older rocks, cut by numerous faults, and intermountain valleys partially filled with unconsolidated Quaternary and Tertiary gravels, alluvium and lake beds. The land surface is typical basin-range with narrow north-south oriented mountain ranges and relatively wider basins.

5.5.1 Structural Aspects

Southeastern Nevada is geologically complex. Many early structures have been obscured by the basin-range faulting and hidden beneath later rocks. Because of lithological similarities in some of the units involved and uncertainty about the exact ages of other units, correlation problems add to the complexity.

The major regional structural features are thrust faults and northeast striking strike-slip faults. (Ref. 6) These features are older and have greater displacements than the later faulting that formed the basins and ranges. At least two periods of thrust faulting occurred, probably during Cretaceous or Eocene time. The faults are generally older than Miocene or younger rocks and older than the later volcanic rocks.

The northeast trending strike-slip faults may have been contemporaneous with late movement of the thrust faults, but apparently continued longer. The last movement on the major strike-slip faults offsets Miocene limestone and later volcanics, which would put the time of last movement at approximately 5 to 8 million years ago.

The normal faults that produced the basins and ranges are later than the major thrust faults and later than most of the volcanics. A few faults of small displacement cut Pliocene or Pleistocene material, but in general the Clark and Lincoln County area is considered to be relatively stable structurally.

The surrogate site is bounded approximately on the west by the Meadow Valley Mountains. The mountains are formed from a thick sequence of rocks from every geologic period except the Precambrian, Jurassic and Cretaceous. The western edge of the mountains is a steep scarp with as much as 2500 feet of elevation above Kane Springs Wash. The eastern side of the range is a more gentle dip slope to Meadow Valley Wash. The rocks are broken by many thrust and normal faults. The thrust faults and major structures are older than Miocene and are overlain by volcanic rocks. Postvolcanic faults are minor except for the fault along the northwest side of the range. (Ref. 6)

The Mormon Mountains form the approximate eastern boundary of the surrogate site and are a broad, roughly circular mass of rock 15 to 20 miles across. Precambrian rocks are exposed at the east and west sides and in the center. The bulk of the surface material is Paleozoic rock which has been thrust over the older material. A number of thrust faults are known but the structure, in general, is poorly understood.

The nearest major structure to the north beyond the surrogate site boundary is the Clover Mountains range. This east-west trending range is composed almost entirely of Tertiary volcanic rocks. The structure is not well known but is thought to be a sequence of rhyolites, tuffs and basalts.

5.5.2 Seismic Characteristics

Nevada can be divided into two parts with respect to earthquake activity: western Nevada, which is closely associated with the activity of California, and central and eastern Nevada, where earthquake activity is more like that of the Western Mountain Region, primarily the Rocky Mountain states. (Ref. 6) California and western Nevada earthquakes have been estimated to represent about 90% of the seismic activity in the contiguous United States. (Ref. 6) Most of these shocks occur at relatively shallow local depths (16-24 km) and along known rupture zones or faults. The shallow focal depths may partly account for the violence of earthquakes in this region.

Less is known about the earthquake history of the Western Mountain Region, of which the Galt site is a part, than of any other area of the United States. Part of this lack of historical data is due to the region's relatively sparse population. Montana, Utah and Nevada have experienced earthquakes of considerable severity, but the wide separation of people and towns has resulted in less damage than would have occurred in more densely settled areas. However, earthquake data are available in this region for the period 1928-1973. Table 5.2 is a list of the earthquakes that were felt or caused damage within about 50 miles (80 km) of the surrogate site. It should be noted that for a single earthquake a number of different locations are listed where the earthquake was felt; thus each line of the table is usually not a separate earthquake. Where the date, time and location coordinates of the earthquake source are the same for more than one line, they represent a single earthquake.

Modified Mercalli intensities are recorded for each location listed in Table 5.2. The minimum intensity recorded is MM III,

TABLE 5.2

EARTHQUAKE HISTORY AND SOURCE NEAR DCNEC SITE

STATE	CITY	INT	N LAT W LONG COORDINATES	---DISTANCE FROM--- SOURCE (KM)	FCINT (KM)	YR MO DA HR MN SEC	N LAT W LONG COORDINATES	MAG DEPTH (KM)
NEVADA	URSINE	V	37.99 114.21	326		32 12 21 06 10	38.73 117.82	7.3
NEVADA	ALAMO	IV	37.37 115.17	277		32 12 21 06 10	38.73 117.82	7.3
NEVADA	HIKO	IV	37.60 115.25	257		32 12 21 06 10	38.73 117.82	7.3
NEVADA	LAS VEGAS	IV	36.14 115.15	368		32 12 21 06 10	38.73 117.82	7.3
NEVADA	PAVACA	IV	37.30 114.38	318		32 12 21 06 10	38.73 117.82	7.3
NEVADA	UVADA	IV	37.72 114.04	349		32 12 21 06 10	38.73 117.82	7.3
UTAH	BERYL	IV	37.92 113.67	373		32 12 21 06 10	38.73 117.82	7.3
NEVADA	BUNKERVILLE	III	36.77 114.13	391		32 12 21 06 10	38.73 117.82	7.3
NEVADA	MESQUITE	III	36.30 114.08	393		32 12 21 06 10	38.73 117.82	7.3
NEVADA	OVERTON	III	36.57 114.45	381		32 12 21 06 10	38.73 117.82	7.3
NEVADA	PIDCHE	III	37.95 114.50	302		32 12 21 06 10	38.73 117.82	7.3
NEVADA	LAS VEGAS	III	36.14 115.15	371		34 01 30 20 17	38.32 118.37	6.5
NEVADA	LAS VEGAS	III	36.18 115.15	485		3- 12 31 18 45	31.80 115.10	7.1
NEVADA	LAS VEGAS	III	36.18 115.15	342		40 05 13 04 36 40.9	32.73 115.45	7.1
NEVADA	LAS VEGAS	VI	36.14 115.15	142		47 04 10 15 53 06.	34.97 116.53	6.4
NEVADA	CARP	IV	37.12 114.52	239		47 04 10 15 54 06.	34.97 116.53	6.4
NEVADA	HENDERSON	IV	36.02 115.30	181		47 04 10 15 53 06.	34.97 116.53	6.4
NEVADA	BOULDER CITY	III	36.02 114.38	190		47 04 10 15 54 06.	34.97 116.53	6.4
NEVADA	BOULDER CITY	VI	36.02 114.38	19		52 05 24 04 15 15.	36.10 114.70	
NEVADA	WHITNEY	VI	36.09 115.04	30		52 05 24 04 15 15.	36.10 114.70	
NEVADA	LAS VEGAS	V	36.18 115.15	41		52 05 24 04 15 15.	36.10 114.70	
NEVADA	OVERTON	IV	36.57 114.45	56		52 05 24 04 15 15.	36.10 114.70	
NEVADA	HENDERSON	III	36.02 115.30	28		52 05 24 04 15 15.	36.10 114.70	
NEVADA	LAS VEGAS	VI	36.14 115.15	375		52 07 21 11 52 14.	35.00 119.03	7.7
NEVADA	WHITNEY	VI	36.09 115.04	381		52 07 21 11 52 14.	35.00 119.03	7.7
NEVADA	BUNKERVILLE	V	36.77 114.13	434		52 07 21 11 52 14.	35.00 119.03	7.7
NEVADA	BOULDER CITY	IV	36.02 114.38	393		52 07 21 11 52 14.	35.00 119.03	7.7
NEVADA	LOGANDALE	IV	36.62 114.55	462		52 07 21 11 52 14.	35.00 119.03	7.7
NEVADA	MCAPA	IV	36.67 114.55	436		52 07 21 11 52 14.	35.00 119.03	7.7
NEVADA	OVERTON	III	36.57 114.45	459		52 07 21 11 52 14.	35.00 119.03	7.7
NEVADA	HIKO	V	37.60 115.25	350		54 07 05 11 13 20.	39.42 118.53	6.6
NEVADA	CALIENTE	IV	37.60 114.52	403		54 07 05 11 13 20.	39.42 118.53	6.6
NEVADA	CARP	IV	37.12 114.52	432		54 07 05 11 13 20.	39.42 118.53	6.6
NEVADA	HIKO	III	37.60 115.25	346		54 07 05 22 07 -1.	39.30 118.50	6.4
NEVADA	HIKO	V	37.60 115.25	355		54 08 24 05 51 31.5	39.58 118.45	6.8
NEVADA	ALAMO	IV	37.37 115.17	376		54 08 24 05 51 31.5	39.58 118.45	6.8
NEVADA	CALIENTE	IV	37.60 114.52	406		54 08 24 05 51 31.5	39.58 118.45	6.8
NEVADA	PIDCHE	IV	37.95 114.50	358		54 08 24 05 51 31.5	39.58 118.45	6.8
NEVADA	CARP	III	37.12 114.52	438		54 08 24 05 51 31.5	39.58 118.45	6.8
NEVADA	MESQUITE	VII	36.80 114.08	457		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	PAVACA	VI	37.50 114.36	373		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	URSINE	VI	37.99 114.21	377		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	CALIENTE	V	37.60 114.52	373		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	CALIFTON	V	37.92 114.68	359		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	ELGIN	V	37.35 114.53	348		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	HIKO	V	37.60 115.25	320		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	LOGANDALE	V	36.62 114.55	438		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	OVERTON	V	36.57 114.45	449		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	PIDCHE	V	37.95 114.50	356		54 12 15 11 11 29.	39.32 118.20	7.1
ARIZONA	LITTLEFIELD	IV	36.67 114.52	463		54 12 15 11 11 29.	39.32 118.20	7.1
NEVADA	ALAMO	IV	37.37 115.17	342		54 12 15 11 11 29.	39.32 118.20	7.1

TABLE 5.2 (cont.)

STATE	CITY	INT	N LAT W LONG COORDINATES	---DISTANCE FROM--- SOURCE (KM)	(CINT) (KM)	GMT YR MO DA HR MN SEC	N LAT W LONG COORDINATES	MAG	DEPTH (KM)
NEVADA	BUNKERVILLE	IV	36.77 114.13	455		54 12 13 11 11 29.	39.32 118.20	7.1	
NEVADA	LAS VEGAS	IV	36.17 115.15	441		54 12 15 11 11 29.	39.32 118.20	7.1	
UTAH	SAINT GEORGE	IV	37.11 113.48	473		54 12 15 11 11 29.	39.32 118.20	7.1	
UTAH	ENTERPRISE	III	37.57 113.72	436		54 12 15 11 11 29.	39.32 118.20	7.1	
NEVADA	BOLDER CITY	VI	36.02 114.38	2		63 03 23 09 28 41.1	36.00 114.90	4.3	
NEVADA	LAS VEGAS	V	36.18 115.15	30		63 03 25 09 28 41.1	36.00 114.90	4.3	
NEVADA	LOGANDALE	V	36.61 114.43	75		63 03 25 09 28 41.1	36.00 114.90	4.3	
NEVADA	OVERTON	V	36.53 114.45	71		63 03 25 09 28 41.1	36.00 114.90	4.3	
ARIZONA	TEMPLE BAR	IV	36.06 114.35	49		63 03 25 09 28 41.1	36.00 114.90	4.3	
NEVADA	HENDERSON	IV	36.02 115.00	9		63 03 25 09 28 41.1	36.00 114.90	4.3	
UTAH	SANTA CLARA	IV	37.13 113.87	146		63 03 25 09 28 41.1	36.00 114.90	4.3	
NEVADA	PARADISE VALLEY	V	36.10 115.09			65 09 25 17 43 44.			
NEVADA	LAS VEGAS	III	36.14 115.15	207		65 09 25 17 43 44.	34.72 116.50	5.7	
NEVADA	BOLDER CITY	III	36.02 114.38	469		66 08 07 17 35 26.7	31.40 114.60	6.3	
NEVADA	CALIENTE	VI	37.00 114.52	35		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	BERYL	VI	37.92 113.87	74		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	CRESTLINE	V	37.65 114.13	29		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	HICK	V	37.60 115.25	25		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	ENTERPRISE	V	37.57 113.72	46		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	GUNLOCK	V	37.24 113.78	39		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	SAINT GEORGE	V	37.11 113.48	63		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	SANTA CLARA	V	37.13 113.87	55		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	UVALDE	V	37.72 114.04	36		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	LAS VEGAS	IV	36.14 115.15	109		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	MCAP	IV	36.67 114.45	90		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	PISCHE	IV	37.92 114.10	66		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	BERYL JUNCTION	IV	37.79 113.85	58		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	IVINS	IV	37.14 113.70	50		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	VEYO	IV	37.34 113.68	46		66 08 15 18 02 36.1	37.40 114.20	6.1	
UTAH	WASHINGTON	IV	37.13 113.50	65		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	ALAMO	III	37.37 113.17	45		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	BOLDER CITY	III	36.02 114.38	164		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	HENDERSON	III	36.02 115.00	169		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	OVERTON	III	36.57 114.45	94		66 08 15 18 02 36.1	37.40 114.20	6.1	
NEVADA	PARADISE	V	37.53 114.38	47		66 09 22 18 57 36.5	37.40 114.20	5.3	
NEVADA	ALAMO	IV	37.37 113.17	85		66 09 22 18 57 36.5	37.40 114.20	5.3	
NEVADA	CALIENTE	IV	37.00 114.52	35		66 09 22 18 57 36.5	37.40 114.20	5.3	
NEVADA	ELGIN	IV	37.35 114.13	29		66 09 22 18 57 36.5	37.40 114.20	5.3	
NEVADA	HICK	IV	37.60 115.25	25		66 09 22 18 57 36.5	37.40 114.20	5.3	
NEVADA	PISCHE	IV	37.92 114.10	66		66 09 22 18 57 36.5	37.40 114.20	5.3	
UTAH	SAINT GEORGE	IV	37.11 113.48	43		66 09 22 18 57 36.5	37.40 114.20	5.3	
NEVADA	MCAP	III	36.67 114.45	90		66 09 22 18 57 36.5	37.40 114.20	5.3	
NEVADA	OVERTON	III	36.57 114.45	94		66 09 22 18 57 36.5	37.40 114.20	5.3	
UTAH	ENTERPRISE	III	37.57 113.72	46		66 09 22 18 57 36.5	37.40 114.20	5.3	
UTAH	CENTRAL	VI	37.43 113.63	179		67 10 04 13 20 14.0	38.30 112.10	5.2	
NEVADA	LAS VEGAS	IV	36.14 115.15	342		68 04 04 02 28 58.9	33.20 116.11	6.5	
NEVADA	LAS VEGAS	III	36.14 115.15	332		69 04 24 22 20 42.9	33.75 116.75	5.9	
NEVADA	EAST LAS VEGAS	IV	36.12 115.77	357		71 02 03 14 00 41.6	34.41 118.40	6.4	
NEVADA	LAS VEGAS	IV	36.17 115.15	354		71 02 03 14 00 41.6	34.41 118.40	6.4	
NEVADA	OVERTON	IV	36.53 114.45	428		71 02 03 14 00 41.6	34.41 118.40	6.4	
NEVADA	LOGANDALE	III	36.61 114.53	427		71 02 03 14 00 41.6	34.41 118.40	6.4	

TABLE 5.2 (cont.)

STATE	CITY	TNT	N LAT W LONG COORDINATES	---DISTANCE FROM---		GNT					N LAT W LONG COORDINATES	MAG	DEPTH (KM)
				SOURCE (KM)	POINT (KM)	YP	MO	DA	HR	MM	SEC		
NEVADA	MCCABE	III	36.67 114.64	423		71	02	03	14	00	41.6	34.41 118.40	6.4
UTAH	BERYL	III	37.93 113.36	575		71	02	03	14	00	41.6	34.41 118.40	6.4
NEVADA	CALIENTE	IV	37.61 114.53	42		71	12	03	17	18	51.5	37.70 115.00	4.8
NEVADA	ALAMO	IV	37.37 115.17	39		71	12	03	17	18	51.5	37.70 115.00	4.8
NEVADA	BRISTOL SILVER MINES	IV	38.04 114.63	52		71	12	03	17	18	51.5	37.70 115.00	4.8
NEVADA	HIKO	IV	37.60 115.24	23		71	12	03	17	18	51.5	37.70 115.00	4.8
NEVADA	PANACA	IV	37.73 114.39	54		71	12	03	17	18	51.5	37.70 115.00	4.8
NEVADA	PIOCH	IV	37.94 114.48	52		71	12	03	17	18	51.5	37.70 115.00	4.8
NEVADA	URBINE	IV	37.93 114.21	76		71	12	03	17	18	51.5	37.70 115.00	4.8
UTAH	MODENA	IV	37.36 113.43	94		71	12	03	17	18	51.5	37.70 115.00	4.8
NEVADA	LAS VEGAS	III	36.17 115.15	170		71	12	03	17	18	51.5	37.70 115.00	4.8
UTAH	CENTRAL	IV	37.42 113.62	187		72	01	03	10	20	38.4	38.60 112.10	4.3
UTAH	CENTRAL	IV	37.42 113.62	180		72	06	02	03	15	48.2	38.60 112.20	4.6

THIS RUN CONTAINS 115 HITS

ENVIRONMENTAL DATA SERVICE-----NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

since this is the lowest MM intensity noticed by people in the affected area. The Modified Mercalli Scale (Table 5.3) is a measure of the effects of an earthquake on people and objects, as determined by experienced observers.

To fully evaluate the seismic risk for the surrogate site area would require a detailed analysis that would include such factors as earthquake focal mechanisms, wave attenuation, site amplification, and distribution of earthquake occurrence in time and space. This type of analysis is beyond the scope of this study and only general comments can be made about the seismic risk.

In summary, based on previous seismic risk zone maps and historical intensity data, the zone within which the surrogate site lies can be described as subject to moderate seismic risk and slight earthquake damage.

5.5.3 Soil Foundation Characteristics and Stability

The major part of the land surface in the Galt surrogate site is composed of lake beds, terraces and fan gravels formed from alluvial debris in large alluvial fans along the mountain fronts bordering most of the site area. The material is primarily unconsolidated to poorly-consolidated, poorly-sorted clay, silt, sand and gravel. It is deformed to some extent and is of low to moderate permeability.

Relatively narrow flood plain deposits occur in the central parts of the area along drainageways. This younger alluvium is composed of unconsolidated silt, sand and clay with some gravels and is generally undisturbed. These deposits are somewhat better sorted than the older alluvium and are more porous and permeable.

TABLE 5.3
MODIFIED MERCALLI INTENSITY
SCALE

- I Not felt except by a very few under especially favorable circumstances.
- II Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
- III Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing truck. Duration estimated.
- IV During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
- V Felt by nearly everyone; many awakened. Some dishes, windows, etc.; broken, a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.
- VI Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.
- VII Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.
- VIII Damage slight to specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbed persons driving motor cars.
- IX Damage considerable in specially designed structures; well designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

- X Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.
- XI Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.
- XII Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

The thickness of the alluvial material is unknown. One well in the south end of the area penetrated 480 feet of sediments and was still drilling clay and cemented gravel. (Ref. 7) Depth to bedrock is thus unknown, as is the type of material underlying the alluvial material, although the older carbonate and volcanic rocks of the surrounding mountains may underlie the valleys at depth.

No quantitative data on engineering properties were available for this site. A bore hole program in the area would be necessary to supply this kind of information.

5.5.4 Volcanic Effects

Evidence of volcanic action is widespread in Nevada, but in the Galt surrogate site area a preliminary search has shown no evidence of recent vulcanism. Work conducted on the Nevada Test Site (Ref. 8,9) has given ages of flows and tuffs from volcanic rocks in Nye and Esmeralda Counties as Miocene-Pleistocene, with sample ages from 2.6 to 6.2 million years (m.y.). (Ref. 8) Closer to the Galt area about 40 miles northwest of the surrogate site, a volcanic tuff in Lincoln County, Nevada, was dated by Potassium-Argon methods as 14 ± 0.5 m.y. As a result of these dates and the lack of any evidence for recent volcanic activity in the immediate Galt area, the risk of volcanic effects is probably very low.

5.5.5 Mineral Resources

The only known mineral resource within the site boundary and immediately adjacent to it in Lincoln County is a vermiculite prospect on the west flank of the Mormon Mountains. Possibly gypsum exists in one area in Township 10S, Range 66E. Lincoln

County ranked fourth among the 17 Nevada counties in 1959 in the value of its mineral production, but the major mining areas are outside the surrogate site area. (Ref. 6)

5.6 HYDROLOGIC CONSIDERATIONS

Much of the data in this section is taken from a 1964 Reconnaissance Appraisal of the Ground-water Resources in the Meadow Valley area (Ref. 10).

5.6.1 Summary of Surrogate Site Hydrology Relevant to a DCNEC

- Surface water through the surrogate site is inadequate to supply the needs of a DCNEC. The flow of the Meadow Valley Wash is intermittent due to the porous nature of the underlying soil.
- The Muddy River, which lies adjacent to the southwest boundary of the Galt site, has a relatively constant flow averaging 47.3 cfs. Pumping to the potential reactor sites and water rights must be studied further to determine the feasibility of using the Muddy River to supply the 3 cfs DCNEC requirement.
- Flash flooding is common in the Meadow Valley drainage basin. As these floods flow downstream to the Galt site, their severity is decreased as a large portion of the water soaks into the ground.
- Ground water beneath the surrogate site generally originates from precipitation in the mountains and valleys of higher elevation to the north. The ground water table appears to be slowly dropping due to irrigation well pumping. Irrigation consumes about 12,000 acre-feet per year, and the annual DCNEC requirement would be about 2,000 acre-feet.
- The quality of the ground water seems to have deteriorated in the past few years due to increasing irrigation seepage. If quality trends continue, the water may become unfit for irrigation in the near future.

5.6.2 Water Supply

5.6.2.1 Surface Water

Surface drainage in the Galt area consists primarily of the Meadow Valley Wash. In general, the Wash originates from ground water sources, then as it flows southward, it is absorbed by the alluvium, reappearing as water is added by other springs. The valleys comprising the headwater drainage areas of Lower Meadow Valley (the Galt site) are shown in Figure 5.10.

A nine-year gaging record at a station below Caliente (about 25 miles north of the surrogate site boundary) for the period 1951-60 shows an average streamflow volume of 8,620 acre-feet per year (12 cfs). Peak flows occur during snowmelt, generally during February and March, and low flows occur during the dry period of September and October. However, flow rarely reaches the mouth of Meadow Valley Wash due to the porosity of the alluvium upstream.

Floods of large magnitude have been reported in the Wash. Devastating floods in 1906, 1910, and 1938 prompted relocation of railroad tracks above the flood plain and construction of two flood control dams in Clover Valley, which contributes flood flows to Meadow Valley Wash.

The reservoirs behind the dams, designed to contain flash floods, have remained empty most of the time since their completion in 1955. Still flash floods from thunderstorms or rapid snowmelt periodically cause road and crop damage in Lower Meadow Valley.

Figure 5.10 Meadow Valley Wash Drainage Basin

5.6.2.2 Ground Water

Most of the Galt site consists of older alluvium which yields small to moderate supplies of water. Younger alluvium, yielding moderate to large supplies of water, is found along main stream channels in the flood plain areas. These and other hydrogeological features are shown in Figure 5.11.

Ground water in the Meadow Valley area is derived mostly from precipitation within the drainage area. Some ground-water underflow through the alluvium underlying the low divide at the north end of the area also contributes to recharge. In areas where precipitation is minimal, such as at the surrogate site, little ground-water recharge occurs.

The general movement of ground water is from the northern part of the area, where most of the recharge occurs, to the southern part, where much of the discharge occurs. Transmission of ground water takes place largely in the alluvium. Where the alluvial cross-sectional area is reduced in the canyons that connect the valleys, the water comes to the surface in springs and flows as surface water until it is lost by evaporation or reabsorbed into the alluvium of the next valley. This occurs at five major canyons in the Meadow Valley Wash.

Ground-water recharge was estimated by a method that assumes a fixed percentage of the average annual precipitation recharges the ground water reservoir (Ref. 11) and that precipitation varies by altitude zones (Ref. 12). Table 5.4 (Ref. 10) shows the precipitation zones and the estimated annual precipitation and recharge by zones for Spring Valley, Patterson Valley, and the remainder of the Meadow Valley drainage area (Figure 5.11).

Figure 5.11 Hydrogeologic Features of the Galt Site

TABLE 5.4
ESTIMATED AVERAGE ANNUAL PRECIPITATION AND GROUND-WATER
RECHARGE IN THE MEADOW VALLEY AREA (Ref. 10)

Precipitation zone (feet)	Area (acres)	Estimated annual precipitation				Estimated recharge from precipitation	
		Range (inches)	Average (inches)	Average (feet)	Average (acre-feet)	Percentage of precipitation	(acre-feet per year)
SPRING VALLEY							
Above 9,000	0	more than 20	21	1.75	0	25	0
8,000 to 9,000	10,600	15 to 20	17.5	1.46	15,500	15	2,300
7,000 to 8,000	69,000	12 to 15	13.5	1.12	77,300	7	5,400
6,000 to 7,000	101,000	8 to 12	10	.83	83,800	3	2,500
below 6,000	<u>3,500</u>	less than 8	6	.50	<u>1,750</u>	0	<u>0</u>
Subtotal (rounded)	184,000				170,000		10,000
PATTERSON VALLEY							
Above 9,000	150	more than 20	21	1.75	260	25	70
8,000 to 9,000	5,400	15 to 20	17.5	1.46	7,900	15	1,200
7,000 to 8,000	23,800	12 to 15	13.5	1.12	26,700	7	1,900
6,000 to 7,000	123,000	8 to 12	10	.83	102,000	3	3,100
below 6,000	<u>114,000</u>	less than 8	6	.50	<u>57,000</u>	0	<u>0</u>
Subtotal (rounded)	266,000				194,000		6,000
REMAINDER OF THE MEADOW VALLEY AREA							
Above 9,000	350	more than 20	21	1.75	610	25	150
8,000 to 9,000	4,500	15 to 20	17.5	1.46	6,600	15	990
7,000 to 8,000	20,200	12 to 15	13.5	1.12	22,600	7	1,600
6,000 to 7,000	202,000	8 to 12	10	.83	168,000	3	5,000
below 6,000	<u>942,000</u>	less than 8	6	.50	<u>472,000</u>	0	<u>0</u>
Subtotal (rounded)	1,170,000				670,000		8,000
Total (rounded)	1,620,000				1,000,000		24,000
Estimated ground-water underflow from Lake Valley to Patterson Wash							<u>3,000</u>
Estimated average annual recharge from all sources to the Meadow Valley area							27,000

From Table 5.4, it is estimated that average annual precipitation over the entire Meadow Valley drainage area totals about 1,000,000 acre-feet and that 2.4% of this, or 24,000 acre-feet, goes to ground-water recharge. Underflow from Lake Valley adds 3,000 acre-feet per year, making a total recharge of 27,000 acre-feet per year from all sources.

5.6.2.3 Kane Valley

Part of the surrogate site extends west of the Meadow Valley Mountains into the Kane Valley. This area is similar to the Meadow Valley Wash area in topography, climatic conditions and drainage. Streamflow occurs only at intervals following high intensity storms and stream channels tributary to the White River have been cut into the otherwise relatively smooth alluvial slopes.

The rocks of Kane Valley are generally similar to those of Lower Meadow Valley. The older rocks consist of Paleozoic carbonates, shales, sandstones, quartzites, conglomerates and Tertiary volcanics. The younger rocks consist of a group of late Tertiary to Quaternary silt, sand and gravel, partly consolidated, and some volcanics and a second group of late Quaternary clays, silts, sands and gravels.

Little well information is available for Kane Valley, but it is inferred that depth to water in the lower part of the valley may be 300 to 400 feet (Ref. 7) and is probably less in the upper part. The general direction of ground-water movement is probably southwestward. Ground-water development in the past has consisted mainly of improving springs for stock water supply.

Data are not available to determine if ground water moves between Meadow Valley and Kane Valley. The Paleozoic carbonates which make up a good portion of the section could provide, through fractures and solution openings, a means for inter-valley flow, but it is not presently known that this occurs. (Ref. 8)

5.6.2.4 The Muddy River Option

A potential source of new water for Lower Meadow Valley is interbasin transfer from the Muddy River, to which Meadow Valley Wash is tributary. This consideration was part of the U.S. Bureau of Reclamation recommendations in 1962 for irrigation of an additional 3000 acres in the valley. The present status of that proposal is not known. Based upon Muddy River streamflow records near the mouth of Meadow Valley Wash, it is assumed that this could be a source of water for a DCNEC. Streamflow data for the 8-year period 1952-59 are shown in Table 5.5 for two gaging stations on the Muddy River near the mouth of the Meadow Valley Wash. Muddy River average flows are adequate to support dry cooling but would be marginal for evaporative cooling.

5.6.3 Water Use

The discussion below is based largely upon 1963 data. (Ref. 10) Complete, current data were not available at the time of this writing.

In terms of volume, most of the water appropriate for use in Meadow Valley is for irrigation. A number of water use permits also include domestic and/or stock water, but the quantity involved is small compared to irrigation use.

TABLE 5.5
ANNUAL DISCHARGE OF MUDDY RIVER (acre-feet)

<u>Year</u>	<u>Muddy River near Moapa^(a)</u>	<u>Muddy River near Glendale^(b)</u>
1952	34,030	39,600
1953	33,250	32,420
1954	33,190	32,140
1955	33,960	39,130
1956	33,160	31,500
1957	35,800	36,900
1958	34,950	33,450
1959	36,030	32,760
Average	34,200 (47.3 cfs)	34,700 (48.0 cfs)

(a) 9 1/2 miles upstream from mouth of Meadow Valley Wash

(b) 2 1/2 miles downstream from mouth of Meadow Valley Wash

The total 1963 pumpage in Meadow Valley was estimated to be 19,000 acre-feet (70% of the average annual recharge). Of this, about 40% returns to the ground-water aquifer as seepage from irrigation. This gives an estimated net draft for 1963 of about 12,000 acre-feet.

Ground-water development has disturbed the dynamic equilibrium (recharge = discharge; storage remains constant) that existed under natural conditions. Many acres of water-using phreatophytes have been cleared, which reduces ground-water depletion by evapotranspiration. This has been offset by diversion of surface and ground water, which increases ground-water depletion. The net result has been a slow local decline of ground-water levels, indicating that water is being taken from storage (mined) and that discharge exceeds recharge. The thickness of the ground-water reservoir is not known because most local wells do not exceed 150 feet in depth.

Nearly all of the estimated 12,000 acre-feet of net draft takes place in the lower part of the valley where the estimated average recharge is only 8,000 acre-feet per year. Therefore, unless additional recharge is being generated from upstream valleys, local overdraft is likely taking place. This could lead to water supply problems for existing users, even without the advent of new developments in water use.

In the Meadow Valley drainage area, the average specific yield* of the uppermost 100 feet of saturated alluvium is about 10% (Ref. 10). Since the alluvium underlies an area of about 800,000 acres, the estimated volume of water stored in the upper 100 feet of alluvium is about 8,000,000 acre-feet,

* specific yield: quantity of water that a unit volume of saturated, permeable material will yield by gravity flow.

or about 300 times the estimated average annual recharge. This computation for the valleys in the Meadow Valley area is summarized in Table 5.6.

TABLE 5.6
GROUND WATER STORED IN VALLEYS
SURROUNDING THE SURROGATE SITE

<u>Valley</u>	<u>Stored water (acre-feet)</u>
Spring Valley	800,000
Eagle Valley	180,000
Rose Valley	80,000
Dry Valley	360,000
Patterson Valley	1,800,000
Panaca Valley	1,400,000
Clover Valley	650,000
Lower Meadow Valley	2,800,000
Total (rounded)	8,000,000

5.6.4 Water Quality

The limited amount of water quality data available is based upon quality requirements for irrigation, especially the salinity hazard as measured by specific conductance. About half of the surface and ground-water samples tested in 1963 (later data were not available at this writing) were classified as of "medium" salinity hazard, the other half as "high" according to the U.S. Department of Agriculture definition. Table 5.7 gives the standards for salinity hazard classification.

TABLE 5.7
CRITERIA FOR SALINITY HAZARD CLASSIFICATION
BY U.S. DEPARTMENT OF AGRICULTURE

<u>Salinity hazard</u>	<u>Specific conductance (micromhos at 25°C)</u>	<u>Classification</u>
Low	0-250	C1
Medium	250-750	C2
High	750-2,250	C3
Very high	>2,250	C4

Locations of the 28 samples taken in October and December 1963 and their chemical analyses are shown in Table 5.8. As can be noted, the lowest specific conductance (classification C1) was found for a high-altitude (7,000 ft) spring in Spring Valley. A gradual increase in mineral concentration in a downstream direction was noted, reflecting the concentration of salts as water evapotranspired. For example, an increase in specific conductance from 575 micromhos in Spring Valley to 711 micromhos in the canyon between Dry and Rose Valleys was noted for the applicable surface water samples. Also, samples from wells in the same area had slightly higher values because of salt concentration from evapotranspiration in surface water reentering the ground-water system.

It also appears that ground-water quality is deteriorating with time. Specific conductance of water samples from a well near Glendale (Ref. 13) has increased from 1,450 micromhos in October 1949 to 3,800 in May 1962 and 4,400 in December 1962. If this trend continues, the ground water may become unsatisfactory for general irrigation purposes.

TABLE 5.8
CHEMICAL ANALYSES OF WATER FROM THE MEADOW VALLEY AREA
(Measurements in ppm)
(Field analyses by the U.S. Geological Survey)

Location	Owner and/or name	Date collected	Calcium (Ca)	Magnesium (Mg)	Bicarbonate (HCO ₃)	Chloride (Cl)	Total hardness	Specific conductance (micromhos at 25°C)	pH	Remarks
<u>Spring Valley</u>										
Sec. 7, T. 3 N., R. 69 E.	Paranip Wash Spring	10-25-63	18	5.1	98	13	66	211	7.8	Surface water sample.
Sec. 7, T. 2 N., R. 70 E.	Spring Valley Creek	10-25-63	51	10	268	39	168	575	7.8	Surface water sample taken at bridge over wash.
Sec. 25, T. 2 N., R. 69 E.	Spring Valley Creek	10-27-63	--	--	--	--	--	528	--	Surface water sample taken at grade site in canyon between Spring and Eagle Valleys.
<u>Eagle Valley</u>										
1N/69-10d1	Paul Bliss well	10-25-63	95	17	412	65	262	927	7.4	
Sec. 15, T. 1 N., R. 69 E.	Spring Valley Creek	10-25-63	--	--	--	--	--	681	--	Surface water sample taken in canyon between Eagle and Rose Valleys.
<u>Rose Valley</u>										
Sec. 28, T. 1 N., R. 69 E.	Spring Valley Creek	10-26-63	72	15	342	48	242	711	8.1	Surface water sample taken in canyon between Rose and Dry Valleys.
1N/69-21a2	James Rosa well	10-25-63	73	9.8	294	43	222	672	7.5	
<u>Dry Valley</u>										
Sec. 28, T. 1 S., R. 68 E.	Meadow Valley Wash	10-27-63	33	4.7	137	41	113	442	8.7	Surface water sample taken at mouth of Condor Canyon. Also: Carbonate (CO ₃), 10 ppm.
1S/69-6d1	Delmoe Brothers - North well	10-26-63	83	12	480	55	257	774	7.5	
<u>Patterson Valley</u>										
3N/66-2d1	Twenty-one mile holding corral well	10-23-63	42	9.0	129	30	142	374	7.8	
<u>Panaca Valley</u>										
1S/68-33c1	C. Kenneth Lee - South well	12-4-63	41	9.8	214	13	143	508	7.7	
2S/67-24d1	Roy Kurt - No. 1 well	10-27-63	82	25	268	117	307	1,120	7.5	
Sec. 4, T. 2 S., R. 68 E.	Panaca Spring	4-15-63	31	9.8	189	15	118	401	8.1	Warm Spring, 2 miles north of Panaca. Also: Silica (SiO ₂), 51; Iron (Fe), 0; Sodium (Na), 38; Potassium (K), 6.8; Sulfate (SO ₄), 29; Fluoride (F), 1.0; Nitrate (NO ₃), 2.6; Boron (B), 0.1; Dissolved solids, 271.
2S/68-5b1	Harry H. Horlocker well	12-4-63	61	31	354	89	280	1,050	7.6	
2S/68-7a1	Panaca LDS Church well	12-4-63	65	21	239	125	250	810	7.8	
2S/68-8b5	U.S.G.S. - Observation well	12-3-63 6-1969	56 22	31 24	619 1,130	107 282	266 154	1,700 3,390	7.6 --	Half mile west of Panaca. Also: Silica (SiO ₂), 35; Sodium (Na) + Potassium (K), 745; Sulfate (SO ₄), 50; Fluoride (F), 12; Nitrate (NO ₃), 0; Boron (B), 1.0; Dissolved Solids, 2,250.
2S/68-8c3	Delmoe Brothers - North well	12-4-63	61	31	308	63	282	1,020	7.8	
2S/68-8c4	Delmoe Brothers - South well	12-4-63	114	68	500	274	565	2,240	7.5	
2S/68-18d2	Don Wadsworth - No. 1 well	10-28-63	157	24	462	117	488	1,780	7.4	
2S/68-19a1	Don Wadsworth - No. 2 well	10-28-63	111	18	426	71	350	1,330	7.5	
3S/67-1b1	Grant Lee - No. 1 well	12-4-63	73	31	328	55	310	1,010	7.7	
3S/67-28c1	Chester Oxborrow - No. 2 well	12-4-63	24	7.5	183	31	91	480	9.2	
<u>Lower Meadow Valley</u>										
4S/66-24a1	Emory Conaway - Middle well	12-5-63	70	15	340	37	216	793	7.7	Two miles south of Caliente.
4S/66-25b1	Emory Conaway - Lower well	12-5-63	53	11	272	26	176	592	7.8	Three miles south of Caliente.
4G/67-18b1	Emory Conaway - Upper well	12-5-63	54	16	260	21	174	522	7.7	Half mile west of Caliente.
7S/67-21c1	James W. Bradshaw well	12-5-63	43	14	340	43	105	812	8.0	Three miles south of Elgin.
12S/65-13b1	Mildred Breedlove well	12-5-63	109	67	264	95	546	1,540	7.9	Near Rox, Nevada.
14S/66-35d1	L. J. McCormick well	10-10-69	132	80	250	32	658	1,450	--	At Glendale. Also: Silica (SiO ₂), 27; Sodium (Na) + Potassium (K), 72; Sulfate (SO ₄), 516; Nitrate (NO ₃), 8.8; Dissolved solids, 951.

5.6.5 Conclusions

From this preliminary analysis, it appears that there would be an adequate water supply for operation of a DCNEC in the Galt area. The source of this supply would possibly be the Muddy River or the ground-water table. Further study is needed to determine the validity of this conclusion. Other areas in which future analysis is needed include:

- relation of the existing water supply to possible needs generated during the construction period and by communities that could result from DCNEC activity, and
- analysis of the possibility that DCNEC construction might accelerate the deterioration of ground-water quality.

5.7 CLIMATOLOGY

The average elevation of the Galt surrogate site is 3000 to 4000 feet, although the elevation drops to about 2000 feet along the southern edge. The highest point within the site boundaries is 5769 feet. Mountains to the west and north extend above 7000 feet. This variation in topography can be expected to result in rather sharp changes in local climate. Specific factors which significantly affect local climates are elevation, slope and exposure. These factors affect winds, temperature and precipitation. Determination of the climatology of a specific location within the Galt site would require a meteorological monitoring program at that site.

In the present instance, meteorological and climatological data (Ref. 14-16) from nearby data sources have been used to estimate the climatological range which can be expected at the DCNEC site. The Las Vegas data are considered to be most representative of the climatological characteristics of most of the Galt site because of proximity and the absence of major topographic barriers between the site and the data source. Data from the other two sources are used primarily to indicate the climatological variability which can be expected. Table 5.9 gives a climatological summary for Las Vegas.

5.7.1 Temperature

The annual average temperature for Las Vegas is about 66°F, with the range of monthly average falling between 43°F in January and 90°F in July. The record high temperature for Las Vegas is 115°F, which occurred in June, and a high of 117°F has been recorded in July in the Las Vegas vicinity (Ref. 14). Temperature data taken at various locations on the Yucca test facility at the Nevada Test Site indicate that elevation exerts

TABLE 5.9
LAS VEGAS CLIMATOLOGY

	<u>Average Temperature</u>	<u>Average Daily Maximum Temperature</u>	<u>Record High Temperature</u>	<u>Average Wind Speed</u>	<u>Peak Wind Gust</u>	<u>Average Precipitation</u>	<u>Average Snow Fall</u>
<u>Month</u>	<u>°F</u>	<u>°F</u>	<u>°F</u>	<u>MPH</u>	<u>MPH</u>	<u>in.</u>	<u>in.</u>
January	43	54	75	6.9	52	.53	.9
February	43	59	79	8.1	54	.44	T
March	55	68	91	9.6	52	.35	T
April	64	78	96	10.6	48	.23	T
May	74	88	106	10.9	52	.08	0.0
June	83	97	115	10.6	46	.04	0.0
July	90	104	114	9.8	64	.50	0.0
August	87	101	113	9.2	55	.48	0.0
September	80	94	107	8.7	54	.34	0.0
October	67	80	99	7.7	52	.20	T
November	52	65	83	6.8	39	.31	0.2
December	45	56	71	6.8	54	.40	0.1
Annual	66	79	115	8.8	64	3.90	1.2

a major influence on daily maximum temperatures. The average decrease in maximum temperature with increasing elevation is about 4°F in the summer and 3°F in the winter. This indicates that in July the average daily maximum temperature at the 3000 feet elevation of the Galt site would be about 100°F and that at 4000 feet would be about 96°F. Similarly, the average daily maximum temperature in January at these elevations would be about 52°F and 48°F, respectively.

The minimum temperatures at the site can be expected to depend upon local flow patterns, which are largely controlled by topography. The Yucca data do not indicate a systematic change in daily minimum temperatures with elevation.

Temperatures at other sites within the general area indicate that the estimates provided above are reasonable. Maximum summer temperatures at Caliente (elevation ~ 4000 feet) and Pioche (elevation ~ 6100) to the north of the Galt site are 100-105°F and 95-100°F, respectively. To the south maximum summer temperatures at Overton (elevation ~ 1200 feet) are typically 115-120°F.

At high ambient temperatures, the thermodynamic efficiency of a DCNEC will be reduced. To assist in assessing the reduction in efficiency the number of hours annually in which the temperature exceeds given values has been estimated. These estimates are given in Figure 5-12. Similar estimates for the Lower Colorado River and Eastern Sacramento Valley surrogate sites have been included for comparison.

Figure 5.12 Number of Hours/Year with Dry-Bulb Temperature Exceeding a Given Value at the Galt Site

5.7.2 Precipitation

Precipitation is highly correlated with elevation in this region. Low elevations on the site can expect about 4 inches of rain each year, while in the higher elevations the annual precipitation may exceed 10 inches. Precipitation is rather evenly distributed throughout the year, except in the dry months of May and June. Relative precipitation maxima occur in January and July. The summer maximum coincides with the annual maximum frequency of thunderstorm occurrence. An average of about 5 thunderstorms can be expected in each of the months of July and August. These thunderstorms are generally associated with the influx of warm, moist tropical air which brings higher than normal humidities.

5.7.3 Wind

Average monthly wind speeds at Las Vegas range between 6.8 mph in December and 10.9 mph in May. Strong winds which are associated with major storms occasionally reach 50 mph. When this occurs, dust and sand are raised. The higher wind speeds are generally associated with southwesterly or northwesterly flow. However, since the Galt site is situated within a valley the wind directions at Las Vegas are probably not representative. Under normal conditions the wind direction on the Galt site will be governed largely by local topographic features. Downslope winds can generally be expected at night and upslope winds during the day. Channeling effects of the topography should be evident.

The seasonal variations of temperatures and wind speed are correlated at Las Vegas, as shown in Figure 5.13. The high temperatures during the summer months are associated with the

Figure 5.13 Seasonal Correlation of Average Wind Speed and Temperature

higher average wind speeds. This same correlation can be expected at the Galt site. There is also a diurnal correlation between wind speed and temperature, as shown in Figure 5.14, for the months of January and July. The data in Figure 5.14 were obtained at about the 3650 foot level on the Nevada Test Site.

Figure 5.14 Diurnal Correlation of Wind Speed and Temperature

5.8 ECOSYSTEMS

5.8.1 Site Characteristics and Community Structure

Southern Nevada is botanically identified as a part of the Mojave Desert which extends into adjacent eastern California and northwestern Arizona. The desert region south is the Sonoran Desert and the desert region to the north is the Great Basin Desert.

The Mojave Desert region is at the fringe of the westerly winds' influence, which at this latitude are not strong enough to bring oceanic climates inward. Rains occur during winter and the early spring months and usually amount to no more than 5 inches of precipitation a year. Temperatures commonly exceed 100°F in the summer and average 50-60°F in the winter. Freezing temperatures may occur during winter nights. The combination of winter rains and cool winter temperatures differentiates the Mojave Desert from other deserts.

5.8.1.1 Vegetation

Characteristic plants of the Great Basin Desert are big sagebrush, Artemisia tridentata; shadscale, Atriplex confertifolia; winterfat, Ceratoides (Eurotia) lanata; and greasewood, Sarcobatus vermiculatus. Characteristic plants of the Sonoran Desert are Creosote bush, Larrea divaricata; ocotillo, Fouquieria splendens; and many species of cacti, including the great saguaro cactus and leguminous shrubs such as Prosopis and Cercidium. In some ways the plant communities of the Mojave Desert form a transition between the communities of Sonoran and Great Basin Deserts. Characteristic plants of the Mojave Desert are the Joshua tree, Yucca brevifolia; Creosote bush, Larrea divaricata; blackbush, Coleogyne ramossima; bur-sage, Ambrosia (Franseria) dumosa; and box-thorn, Lycium andersonii.

The texture and salt content of the soil and topography of the land interact or operate independently to produce an interesting sequence of desert communities (Figure 5.15). The high mountain areas and mesa tops above 5000 ft elevation support coniferous forests of pine, especially single-leaf pinyon, Pinus monophylla, and several species of Juniperus. Highest elevations support white fir, Abies concolor.

Descending from the highlands and mesa tops, one notices accompanying differences in soil texture and vegetation. The high slopes (Upper Bajada) have very coarse stony soils and support stands of Coleogyne ramossima; Yucca brevifolia may also be present. Lower elevations (Lower Bajada) contain finer textured soils. Larrea divaricata, Lycium andersonii, Grayia spinosa, and Ambrosia dumosa commonly occur here.

On the floor of the Mojave Desert, where there is little drainage, storm water accumulates and often forms lakes. These areas are called playas. When dry, their surface is smooth, hard, and generally devoid of any vascular vegetation. Larrea divaricata and Ambrosia dumosa will often extend to the edge of these bare lake beds. In some cases when soil in the lower elevation becomes alkaline, there are wide belts of Atriplex confertifolia and Kochia californica surrounding these playas.

The understory herbaceous plants and Mojave Desert shrubs are diverse as far as species composition is concerned. Most are annuals. However, productivity is low and varies greatly from year to year, depending upon the amount and seasonal distribution of rainfall. (Ref. 17)

Shrub canopies occupy little ground in the Mojave Desert. The canopy cover of Creosote bush communities ranges from 6% to 17% of ground area. (Ref. 18) The amount of ground

Figure 5.15 Diagrammatic Representation of Vegetation Zonation in a Closed Valley System in Southern Nevada (Ref. 18)

cover provided by herbaceous species was also low, ranging between 6% and 16%, depending on site characteristics.

Table 5.10 lists other plant species encountered in the Creosote bush community.

When Mojave Desert vegetation is destroyed, alien weeds are among the first plants to recolonize the bare area. Notable among these are Russian thistle, Salsola kali, and red brome, Bromus rubens. (Ref. 19)

Although the herbaceous plants of the Mojave Desert provide some forage for livestock, sheep, and cattle, the desert is regarded as marginal rangeland. The most important sheep forage is provided by the shrub Ceratoides lanata.

5.8.1.2 Riparian Communities

The Meadow Valley Wash and Muddy River are the principal drainages in the Galt area. The presence of running water provides for a unique vegetational regime which occurs nowhere else in the vicinity. Trees, grasses, and submergent aquatic plants are present in these riparian conditions. Trees provide nesting sites for hawks and other avian species and enable them to raise their young out of reach from ground predators. Certain species of raptors almost totally confine their nesting to these stream-side areas. Trees also provide shade and cover for many wildlife species.

Aquatic situations are important for amphibian reproduction and development. Certain desert rivers (the Muddy) may be important for fishing and probably contain several species of fish that are classified as endangered. Care should be taken so that these unique riverine communities are not disturbed.

TABLE 5.10
COMMON PLANTS OF A CREOSOTE BUSH COMMUNITY IN
SOUTHERN NEVADA AND PERCENT GROUND COVER (%C)

<u>Shrubs</u>	<u>%C</u>	<u>Annuals (Cont.)</u>	<u>%C</u>
<u>Larrea divaricata</u>	6.1	<u>Monoptilon bellidiforme</u>	+
<u>Ephedra nevadensis</u>	1.7	<u>Chorizanthe thurberi</u>	+
<u>Lycium andersonii</u>	1.0	<u>Cryptantha pterocarya</u>	0.2
<u>Ambrosia dumosa</u>	1.0	<u>Gilia spp.</u>	0.5
<u>Krameria parvifolia</u>	1.0	<u>Eriogonum reniforme</u>	0.4
<u>Ceratoides lanata</u>	0.4	<u>Eriogonum nidularium</u>	+
<u>Menodora spinescens</u>	0.3	<u>Phacelia fremonti</u>	+
<u>Acamptopappus</u>		<u>Oenothera sp.</u>	+
<u>shockleyi</u>	0.2	<u>Chaenactis</u>	
<u>Coleogyne ramosissima</u>	0.1	<u>carphoclinia</u>	0.3
		<u>Chaenactis xanthiana</u>	0.4
Total	11.8	<u>Descurainia pinnata</u>	0.1
		<u>Linanthus dichotomus</u>	+
<u>Perennial Herbs</u>		<u>Pectocarya platycarpus</u>	+
		<u>Calycoseris wrightii</u>	+
<u>Oryzopsis hymenoides</u>	1.2	<u>Glyptopleura marginata</u>	+
<u>Mirabilis pudica</u>	<0.1	<u>Ipomopsis polycladon</u>	+
		<u>Streptonthella</u>	
Total	1.2	<u>longirostris</u>	+
		<u>Cryptantha sp.</u>	+
<u>Annuals</u>		<u>Chorizanthe rigida</u>	+
		<u>Eriogonum trichopes</u>	+
<u>Chaenactis stevoides</u>	4.0	<u>Festuca octoflora</u>	0.9
<u>Mentzelia veatchiana</u>	0.5	<u>Pectocarya setosa</u>	0.2
<u>Eriophyllum pringeli</u>	0.1	<u>Eriogonum sp.</u>	+
<u>Bromus rubens</u>	0.3	<u>Escholtzia glyptosperma</u>	+
<u>Amsinckia tessellata</u>	1.5	<u>Lepidium lasiocarpum</u>	+
<u>Cryptantha</u>		<u>Rafinesquia neomexicana</u>	+
<u>circumscissa</u>	0.7	Total	10.8
<u>Oxytheca perfoliata</u>	0.3		
<u>Malacothrix glabrata</u>	0.2	GRAND TOTAL	23.8
<u>Langloisia schotii</u>	+		
<u>Nama demissum</u>	+	+ = <0.1 percent cover	
<u>Lupinus flavoculatus</u>	0.2		

5.8.1.3 Wildlife

Mammals. Mammals are an important component of the Galt ecosystem. Certain species, such as the mule deer and big-horn sheep, provide sport for hunters. In 1973, 98 deer and 2 bighorn sheep were harvested in the vicinity of the site. (Ref. 20) Some mammals also provide income to trappers and hunters from the sale of furs. During 1973, 11 gray fox, 122 bobcat, 47 coyote, and 5 badger were harvested near the site. (Ref. 21) A variety of other mammals (bats, rodents, carnivores, etc.) are not considered game or furbearers but are important to the proper functioning of ecosystems. Table 5.11 lists the mammals which have been observed in the desert National Wildlife Refuge (Ref. 22) and other areas (Ref. 23) near the DCNEC site and describes the habitats where they are most frequently found.

Birds. Birds, the most colorful and conspicuous faunal elements of terrestrial ecological systems, attract the attention of scientists and amateurs alike. Observing and hunting of wild birds also provide hours of outdoor recreation.

The birds of Nevada have been studied by a number of scientists (Ref. 24,25,26) and records of their distribution are fairly well documented. The Pahrnagat National Wildlife Refuge (Ref. 27) and Desert National Wildlife Range (Ref. 28) provide lists of seasonal distribution and abundance which are most pertinent to the Galt Site. Table 5.12 lists 245 bird species observed in these areas.

Reptiles and Amphibians. Table 5.13 lists the amphibians of the Desert National Wildlife Range. Most of these can be expected to occur in suitable habitats at or near the site.

TABLE 5.11
LIST OF THE MAMMALS OF THE DESERT NATIONAL
WILDLIFE RANGE (FROM REF. 22)

<u>Species</u>	<u>Habits and Habitat</u>
Yuma Myotis (<u>Myotis yumanensis</u>)	Occasional. A colonial cave bat.
Long-eared Myotis (<u>Myotis evotis</u>)	Found in or just below timbered areas. Uses niches in rocks, trees or buildings to roost.
Long-legged Myotis (<u>Myotis volans</u>)	Common in the tree zones.
California Myotis (<u>Myotis californicus</u>)	Common in the lower desert areas below the tree zones. A colonial cave bat.
Small-footed Myotis (<u>Myotis subulatus</u>)	Usually found below 6,500 feet. Uses niches in rocks, trees, or buildings to roost.
Silver-haired Bat (<u>Lasionycteris noctivagans</u>)	Found occasionally.
Western Pipistrel (<u>Pipistrellus hesperus</u>)	The common small bat found throughout the Wildlife Refuge Range below the ponderosa pine zone.
Big Brown Bat (<u>Eptesicus fuscus</u>)	Common. A colonial cave bat.
Hoary Bat (<u>Lasiurus cinereus</u>)	Of rare occurrence at lower elevations.
Western Big-eared Bat (<u>Corynorhinus rafinesquii</u>)	Found occasionally.
Pallid Bat (<u>Antrozous pallidus</u>)	A common cave bat.
Mexican Freetail Bat (<u>Tadarida mexicana</u>)	A common cave bat.
Blacktail Jackrabbit (<u>Lepus californicus</u>)	Common throughout the open desert at lower elevations, but occasionally found into the ponderosa pines.

TABLE 5.11 (cont.)

<u>Species</u>	<u>Habits and Habitat</u>
Mountain Cottontail (<u>Sylvilagus nuttallii</u>)	Generally found at the higher elevations in the tree zones and usually in brushy situations.
Desert Cottontail (<u>Sylvilagus audubonii</u>)	Common in washes at lower elevations although it will range up into the tree zones.
Townsend Ground Squirrel (<u>Citellus townsendii</u>)	Only at Indian Springs.
Rock Squirrel (<u>Citellus variegatus</u>)	A common but not abundant large squirrel, found in rocky areas throughout the Sheep Range
Whitetail Antelope Squirrel (<u>Citellus leucurus</u>)	Common throughout the lower elevations and occasional in the lower tree zone.
Colorado Chipmunk (<u>Eutamias quadrivittatus</u>)	Found only on the Sheep Range, mainly in the ponderosa pine zone.
Cliff Chipmunk (<u>Eutamias dorsalis</u>)	Found only on the Sheep and Las Vegas Ranges, primarily in the tree zones.
Valley Pocket Gopher (<u>Thomomys bottae</u>)	This species is widely scattered throughout all zones.
Little Pocket Mouse (<u>Perognathus longimembris</u>)	Inhabits the firmer soils above the valley floor as high as 6,500 feet.
Great Basin Pocket Mouse (<u>Perognathus parvus</u>)	Found sparingly within the range of the little pocket mouse.
Longtail Pocket Mouse (<u>Perognathus formosus</u>)	Generally abundant below the tree zone where stones are scattered over the soil.
Merriam Kangaroo Rat (<u>Dipodomys merriami</u>)	Common below 6,500 feet.

TABLE 5.11 (cont.)

<u>Species</u>	<u>Habits and Habitat</u>
Great Basin Kangaroo Rat (<u>Dipodomys microps</u>)	Usually inhabits the sandy loose soil around the dry lakes; also found in the Joshua tree zone.
Desert Kangaroo Rat (<u>Dipodomys deserti</u>)	Not common. Present only in the deep windblown sandy areas of the desert floor.
Western Harvest Mouse (<u>Reithrodontomys megalotis</u>)	Widely scattered but nowhere common. Usually found near water.
Canyon Mouse (<u>Peromyscus crinitus</u>)	Found everywhere in rocky situations.
Cactus Mouse (<u>Peromyscus eremicus</u>)	This is the common white-footed mouse of the lower desert, but it occurs up into the Joshua tree zone.
Deer Mouse (<u>Peromyscus maniculatus</u>)	Common throughout in moist situations. It is replaced by the cactus mouse in the low desert areas and the canyon mouse in rocky situations.
Brush Mouse (<u>Peromyscus boylii</u>)	Rare, but widely scattered in brush type habitat at most elevations.
Pinyon Mouse (<u>Peromyscus truei</u>)	Generally found associated with pinyon pines and junipers in rocky situations.
Southern Grasshopper Mouse (<u>Onychomys torridus</u>)	Wide-spread but not abundant, generally below 5,500 feet.
Desert Woodrat (<u>Neotoma lepida</u>)	Abundant from the lowest elevations up into the pinyon-juniper zone and frequent as high as 9,000 feet. Houses of small stones, twigs, and cactus are a common sight.
Bushytail Woodrat (<u>Neotoma cinerea</u>)	Most common above the pinyon-juniper zone. Collected at 11,000 feet.

TABLE 5.11 (cont.)

<u>Species</u>	<u>Habits and Habitat</u>
House Mouse (<u>Mus musculus</u>)	Found only around dwellings occupied by man.
Porcupine (<u>Erethizon dorsatum</u>)	Not common. Usually in timber.
Coyote (<u>Canis latrans</u>)	Common throughout the area.
Red Fox (<u>Vulpes fulva</u>)	Occurrence based on skull found in the Sheep Range.
Kit Fox (<u>Vulpes macrotis</u>)	Found throughout at lower elevations, usually observed around the dry lake beds and sand dunes.
Gray Fox (<u>Urocyon cinereoargenteus</u>)	Found throughout the area.
Ringtail Cat (<u>Bassariscus astutus</u>)	Rare. Reported from the Corn Creek Field Station and in the Sheep Range.
Badger (<u>Taxidea taxus</u>)	Fairly common through the lower elevations, but may be found well in the tree zones.
Spotted Skunk (<u>Spilogale gracilis</u>)	Occasional in the Sheep Range in the tree zones.
Striped Skunk (<u>Mephitis mephitis</u>)	Rare. Observed only on the Sheep Range in the tree zones.
Mountain Lion (<u>Felis concolor</u>)	(Cougar, Puma). Rare at higher elevations in the Sheep Range
Mule Deer (<u>Odocoileus hemionus</u>)	Common on the Sheep Range.
Pronghorn (<u>Antilocapra americana</u>)	(Antelope). Native herds roam off and on the Wildlife Range along the northern boundary.
Bighorn Sheep (<u>Ovis canadensis</u>)	Widespread on the mountain ranges of the Desert Wildlife Range, but nowhere abundant.

TABLE 5.11 (cont.)

<u>Species</u>	<u>Habits and Habitat</u>
Wild Burro (<u>Equus assinus</u>)	Rare. Occasionally roam onto Wildlife Range from adjoining Public Domain Lands.

TABLE 5.12
BIRDS OF THE DESERT NATIONAL WILDLIFE RANGE*

Species	Season				Species	Season			
	S	S	F	W		S	S	F	W
Common Loon	r		r		Common Goldeneye	o		o	o
Eared Grabe	o		o		Bufflehead	u		u	u
Western Grabe	o		o		Ruddy Duck	o		o	o
Pied-billed Grebe				r	Hooded Merganser	r			
Double-crested Cormorant	r	r	r	r	Common Merganser	o		o	o
Great Blue Heron	o	o	o		Turkey Vulture	u	u	u	
Green Heron	r				Goshawk	f	f	f	f
Common Egret	o		o		Sharp-shinned Hawk	u	u	u	o
Snowy Egret	o	o	o		Cooper's Hawk	u	u	u	u
Black-crowned Night Heron	o	o	o		Red-tailed Hawk	u	u	u	o
Least Bittern	r				Swainson's Hawk	u		u	
American Bittern	o				Golden Eagle	c	u	u	o
White-faced Ibis	o	o	o		Bald Eagle	r		r	
Canada Goose	o		o		Marsh Hawk	u	o	u	o
White-fronted Goose	o		o		Osprey	r		r	
Mallard	c		c	c	Prairie Falcon	u	u	u	o
Gadwall	u		u	u	Peregrine Falcon	r	r	r	r
Pintail	u		u	u	Pigeon Hawk	o	r	o	o
Green-winged Teal	c	u	u	c	Sparrow Hawk	c	c	c	c
Blue-winged Teal	u		u	u	Gambel's Quail	c	c	c	c
Cinnamon Teal	c	o	c	o	Sandhill Crane	r		r	
American Widgeon	o		o	o	Virginia Rail	r			
Shoveler	o		o	o	Sora	o	r	o	
Wood Duck	o				Common Gallinule	o		o	o
Redhead	u		u	u	American Coot	c	c	c	c
Ring-necked Duck	o		o	o					
Canvasback	r		r	o					
Lesser Scaup	o		o	o					

c = common o = occasional S = March-May F = September-November
u = uncommon r = rare S = June-August W = December-February

*This list of 245 species represents observations and studies reported primarily since 1936.

TABLE 5.12 (cont.)

Species	Season			
	S	S	F	W
Snowy Plover			r	
Killdeer	u	o	o	
Black-bellied Plover			r	
Common Snipe	u		o	
Long-billed Curlew	o		o	
Spotted Sandpiper	u	u	u	
Solitary Sandpiper	r		o	
Willet			o	
Greater Yellowlets	o	o	o	
Lesser Yellowlets		r		
Least Sandpiper	u		u	
Long-billed Dowitcher	o		o	
Western Sandpiper	o	u	o	
Marbled Godwit			o	
American Avocet	u		u	
Black-necked Stilt	o		o	
Wilson's Phalarope	o			
Northern Phalarope	o			
California Gull	o		o	
Ring-billed Gull	o			
Bonaparte's Gull	u		u	
Black Tern	o		o	
Band-tailed Pigeon	o	r	o	
White-winged Dove	r	r	r	
Mourning Dove	c	c	c	
Ground Dove		r		
Yellow-billed Cuckoo	o	o	o	
Roadrunner	o	o	o	o
Barn Owl	u	o	u	
Screech Owl	o	o	u	o
Flammulated Owl	u	c	u	
Great Horned Owl	o	o	o	o

Species	Season			
	S	S	F	W
Pygmy Owl	u	u	u	u
Burrowing Owl	o	o	o	
Long-eared Owl	u	o	u	o
Short-eared Owl				r
Saw-whet Owl	o	o	o	
Whip-poor-will		r		
Poor-will	u	c	u	
Common Nighthawk	u	c	u	
Lesser Nighthawk	u	c	u	
Vaux's Swift	o		o	
White-throated Swift	u	c	u	
Black-chinned Hummingbird	u		u	
Costa's Hummingbird	o	u		
Anna's Hummingbird		u	u	
Broad-tailed Hummingbird	u	c	u	
Allen's Hummingbird	o			
Rufous Hummingbird	o	c	u	
Calliope Hummingbird		u		
Belted Kingfisher	o		o	
Yellow-shafted Flicker	r		r	
Red-shafted Flicker	u	o	u	u
Lewis' Woodpecker	o		o	
Yellow-bellied Sapsucker	c	c	c	
Williamson's Sapsucker	o	u	o	o
Hairy Woodpecker	o	o	o	o
Ladder-backed Woodpecker	c	o	c	c

TABLE 5.12 (cont.)

Species	Season				Species	Season			
	S	S	F	W		S	S	F	W
Eastern Kingbird		o			Brown Creeper	u	u	u	u
Western Kingbird	c	c	c		House Wren	c	u	c	
Scissor-tailed Flycatcher	r				Bewick's Wren	o	u	o	
Ash-throated Flycatcher	o	c	o		Cactus Wren	o	u	o	r
Black Phoebe	u	u	u		Long-billed Marsh Wren	o	o	o	o
Say's Phoebe	c	c	c	u	Canyon Wren	o	o	o	o
Traill's Flycatcher	o	u	o		Rock Wren	c	c	c	c
Hammond's Flycatcher	o		o		Mockingbird	c	c	c	o
Dusky Flycatcher	u	c	u		Brown Thrasher	r	r		
Gray Flycatcher	o	c	o	o	Bendire's Thrasher		u		
Western Flycatcher	o	c	o		LeConte's Thrasher	o	u	o	o
Western Wood Pewee	o	u	o		Crissal Thrasher	o	o	o	o
Olive-sided Flycatcher	o	u	o		Sage Thrasher	u	o	u	u
Vermilion Flycatcher	o	o	o		Robin	c	u	c	c
Horned Lark	c	c	c	c	Hermit Thrush	o	c	o	
Violet-green Swallow	c	c	c		Swainson's Thrush	u		u	
Tree Swallow	u	c	u		Western Bluebird	o	c	o	o
Bank Swallow	r				Mountain Bluebird	u		o	u
Rough-winged Swallow	u	o	u		Townsend's Solitaire	u	o	u	c
Barn Swallow	u	o	u		Blue-gray Gnatcatcher	c	c	c	c
Cliff Swallow	o	u	o		Black-tailed Gnatcatcher	o	o	o	o
Steller's Jay	u	u	u	u	Golden-crowned Kinglet	u	o	r	u
Scrub Jay	c	c	c	c	Ruby-crowned Kinglet	u	o	u	u
Common Raven	u	u	u	u	Water Pipit	c		c	c
Common Crow	o		o	u	Bohemian Waxwing				r
Pinyon Jay	c	c	c	c	Cedar Waxwing	u		u	o
Clark's Nutcracker	c	c	c	c	Phainopepla	c	c	c	c
Mountain Chickadee	c	c	c	c	Loggerhead Shrike	c	c	c	c
Plain Titmouse	o	u	o	o	Starling	u	u	u	c
Verdin	u	o	u	u	Hutton's Vireo	o			
Common Bushtit	c	c	c	c	Bell's Vireo	o			
White-breasted Nuthatch	u	c	u	u	Gray Vireo	o	u	o	
Red-breasted Nuthatch	o	u	o	o					
Pygmy Nuthatch	c	c	c	c					

TABLE 5.12 (cont.)

Species	Season			
	S	S	F	W
Solitary Vireo	o	c	o	
Red-eyed Vireo		r	r	
Warbling Vireo	o		o	
Black-and-white Warbler	r	r		
Tennessee Warbler	r		r	
Orange-crowned Warbler	u		u	u
Nashville Warbler	u		u	
Virginia's Warbler	u	c	u	
Lucy's Warbler	o			
Parula Warbler			r	
Yellow Warbler	u	o	u	
Black-throated Blue Warbler			r	
Myrtle Warbler	r			r
Audubon's Warbler	c	c	c	u
Black-throated Gray Warbler	u	c	u	r
Townsend's Warbler	u		u	
Grace's Warbler	c	c		
Northern Waterthrush	o		o	
MacGillivray's Warbler	u	c	c	
Yellowthroat	o	c	o	
Yellow-breasted Chat	u	u	u	
Wilson's Warbler	c	u	u	
American Redstar	o		o	
Painted Redstar	r	r		
House Sparrow	c	c	c	c
Western Meadowlark	c	o	c	c
Yellow-headed Blackbird	c	o	c	o
Red-winged Blackbird	c	u	c	c
Hooded Oriole	u	o	o	
Scott's Oriole	u	u	u	
Bullock's Oriole	u	c	u	
Brewer's Blackbird	c	o	c	o
Brown-headed Cowbird	u	c	u	o

Species	Season			
	S	S	F	W
Western Tanager	u	c	u	
Summer Tanager	r	r	r	
Rose-breasted Grosbeak	r			
Black-headed Grosbeak	u	c	u	
Blue Grosbeak	u	u	u	
Indigo Bunting	o		r	
Lazuli Bunting	o	u	o	
Evening Grosbeak	o		o	u
Cassin's Finch	c	c	c	c
House Finch	c	c	c	c
Pine Siskin	c	c	c	c
American Goldfinch	o		o	o
Lesser Goldfinch	u	o	u	o
Red Crossbill	u	u	u	u
Green-tailed Towhee	c	c	c	
Rufous-sided Towhee	c	c	c	c
Lark Bunting	u		u	o
Savannah Sparrow	o		u	o
Vesper Sparrow	o		o	
Lark Sparrow	u		u	
Black-throated Sparrow	c	c	c	o
Sage Sparrow	c		c	c
Slate-colored Junco	o		o	
Oregon Junco	c		c	c
Gray-headed Junco	u	c	u	
Tree Sparrow	r			
Chipping Sparrow	c	c	c	
Brewer's Sparrow	c	u	c	
Black-chinned Sparrow		o		
White-crowned Sparrow	c		c	c
Golden-crowned Sparrow	r		r	r
Fox Sparrow	c		c	c
Lincoln's Sparrow	u		u	
Song Sparrow	c		c	c

TABLE 5.13
AMPHIBIANS AND REPTILES OF THE DESERT NATIONAL
WILDLIFE RANGE

Species

Habits and Habitat

(Amphibians)

Pacific Treefrog
(Hyla regilla)

Rare. Found around water at
Corn Creek.

Bullfrog
(Rana catesbeiana)

Common at Corn Creek.

(Reptiles)

Desert Tortoise
(Gopherus agassizi)

Commonly seen between March
and September in flats and
surrounding foothills.

Banded Gecko
(Coleonyx variegatus)

A nocturnal lizard found under
rocks and fallen yuccas up to
4,000 feet. Most common in
the spring.

Chuckwalla
(Sauromalus obesus)

Uncommon. A large lizard found
sunning itself on large rocks
and boulders on barren hills
from 2,000 to 4,000 feet in
elevation.

Zebra-tailed Lizard
(Callisaurus draconoides)

Common in gravelly and sandy
washes in the morning and evening
during summer. A fast lizard
which runs with tail up.

Collared Lizard
(Crotaphytus collaris)

A rock-dwelling lizard found
in mountainous and hilly areas
on slopes and washes. Seen
most commonly on mornings of
spring and early summer.

Leopard Lizard
(Crotaphytus wislizenii)

One of the larger lizards,
found in flat areas with loose
soil and scattered low vegeta-
tion up to 7,000 feet.

Desert Spiny Lizard
(Sceloporus magister)

A good climber found in bushy
plains and lower slopes of
mountains, often near water in
the summer.

TABLE 5.13 (cont.)

Species

Habits and Habitat

(Reptiles, Cont.)

Western Fence Lizard
(Sceloporus occidentalis)

Common lizard in wooded rocky areas, often on fence posts, logs, and sides of buildings.

Sagebrush Lizard
(Sceloporus graciosus)

Found in basin sagebrush flats into pinyon-juniper hillsides.

Side-blotched Lizard
(Uta stansburiana)

The most abundant lizard at lower elevations (below 5,000 feet), in gravelly and rocky areas.

Desert Horned Lizard
(Phrynosoma platyrhinos)

Commonly seen in valleys and flats below 6,500 feet sunning itself in sandy or gravelly areas.

Desert Night Lizard
(Xantusia vigilis)

Common small nocturnal lizard found on semi-arid flats below 5,200 feet under fallen Joshua trees and rotten logs.

Western Skink
(Eumeces skiltonianus)

Rare. Found near water at Corn Creek under logs or bark and in pinyon-juniper associated with moisture.

Western whiptail
(Cnemidophorus tigris)

Abundant on fine to hard-packed soils with sparse vegetation.

Spotted Leaf-nose Snake
(Phyllorhynchus decurtatus)

Nocturnal snake found in open flats and sandy areas, often near creosote bushes.

Coachwhip
(Masticophis flagellum)

A common diurnal snake found near mesquites in low rocky foothills and on gravelly desert floor.

Striped Whipsnake
(Masticophis taeniatus)

Diurnal. Found in a variety of habitats in foothills and mountains, often near sagebrush.

TABLE 5.13 (cont.)

<u>Species</u>	<u>Habits and Habitat</u>
(Reptiles, Cont.)	
Western Patch-nosed Snake (<u>Salvadora hexalepis</u>)	Diurnal. Found in low brushy areas around 5,500 feet elevation.
Glossy Snake (<u>Arizona elegans</u>)	Nocturnal. Occurs in a variety of habitats. Adults reach a length of 17 to 46 inches.
Gopher Snake (<u>Pituophis melanoleucus</u>)	A diurnal snake often mistaken for a rattlesnake. Seen often in vegetated valleys and washes.
Common Kingsnake (<u>Lampropeltis getulus</u>)	Usually diurnal but may be active at night in summer months. Found near water at Corn Creek.
Long-nosed Snake (<u>Rhinoceilus lecontei</u>)	Nocturnal. May be found along roadways at night. Adults reach 20 to 38 inches in length.
Western Ground Snake (<u>Conora semiannulata</u>)	Nocturnal. Found in sandy areas up to 4,000 feet in elevation; may be seen at night on roads.
Western Shovel-nosed Snake (<u>Chionactis occipitalis</u>)	Rare. A small nocturnal snake (6 to 15 inches long) found in sandy areas and washes. Active in the spring.
Sonora Lyre Snake (<u>Trimorphodon lambda</u>)	Rare. Found in rocky areas into tree zones. A good climber. Adults found 21 to 41 inches in length.
Night Snake (<u>Hypsiglena torquata</u>)	Nocturnal. Found under rocks, dead branches of Joshua trees, and mesquite, and other surface litter.

TABLE 5.13 (cont.)

<u>Species</u>	<u>Habits and Habitat</u>
(Reptiles, Cont.)	
Speckled Rattlesnake (<u>Crotalus mitchelli</u>)	Nocturnal. A poisonous snake found generally in washes. Adults are 22 to 40 inches long.
Sidewinder (<u>Crotalus cerastes</u>)	Poisonous, nocturnal snake found in sandy areas and gravelly washes up to 5,000 or 6,000 feet in altitude. Adults reach 17 to 30 inches in length.

Hypothetical Species

(Amphibians)

Western Spadefoot (<u>Scaphiophus hammondi</u>)	This toad is found near Indian Springs (not on the Range) where the soil is sandy or gravelly.
Red-spotted Toad (<u>Bufo punctatus</u>)	Nocturnal. Found in rocky canyons and washes. Included on distributional basis only.

(Reptiles)

Desert Iguana (<u>Dipsosaurus dorsalis</u>)	Found in sandy areas with creosote bush. Seen out even in very hot weather in areas up to 4,000 feet. Included on distributional basis only.
Long-tailed Bush Lizard (<u>Urosaurus graciosus</u>)	Diurnal. Found in loose sand near creosote bush. Included on distributional basis only.
Gila Monster (<u>Heloderma suspectum</u>)	The only poisonous lizard in North America. Found near Indian Springs on desert floor and valleys. This lizard reaches 24 inches in length.

TABLE 5.13 (cont.)

SpeciesHabits and HabitatHypothetical Species (Cont.)

(Reptiles, Cont.)

Western Blind Snake
(Leptotyphlops humilis)

Nocturnal. Found on rocky hillsides with patches of loose soil. Included on distributional basis only.

Mojave Rattlesnake
(Crotalus scutulatus)

A poisonous snake found in areas of scrubby growth of creosote and mesquite brush. Included on distributional basis only.

Western Black-headed Snake
(Tantilla planiceps)

Nocturnal. Found in rocky edges of washes in valleys and hillsides. May be seen on rocks on warm nights. Included on distributional basis only.

Endangered Species. Several wildlife species which occur on or near the Galt site are classified as "threatened" or "status undetermined" by the United States Department of Interior in their 1973 publication, Threatened Wildlife of the United States. These species require special consideration whenever their habitats are in danger of being disrupted by man.

Birds:

Southern Bald Eagle	T
Prairie Falcon	T
Peregrine Falcon	T
Ferruginous Hawk	SU
Western Burrowing Owl	SU

Mammals:

Spotted Bat	T
-------------	---

Reptiles and Amphibians:

Gila Monster	SU
--------------	----

Fish:

Pahranagat Bonytail	T
<u>Gila robusta jordani</u>	
Moapa Dace	T
<u>Moapa coriacea</u>	
White River Sucker	T
<u>Catostomus clarki</u>	
<u>intermedius</u>	

(Legend: T = Threatened; SU = Status Undetermined)

5.8.2 Impacts

5.8.2.1 Effects of Construction

The effects of construction at the Galt site can generally be related to the acreage involved. The greatest potential for soil disturbances results from construction of the buildings, roads, railroads, and transmission lines. In all

construction activities, some habitat will be lost and some wildlife will be displaced into surrounding areas. Most of these displaced animals (especially nonavian species) will no doubt perish, since surrounding habitat will probably be at its carrying capacity. Noise and dust from construction activities and the sight of humans and their machinery will interfere with normal behavior of sensitive animal species. A study conducted on wild turkeys in Pennsylvania indicated that they avoided open areas because they were disturbed by the sight of humans. (Ref. 29) Since the Mojave Desert vegetation is sparse, we could expect that sensitive animals such as the Prairie Falcon would be displaced to areas removed from human disturbances. Areas frequented by endangered species should be kept as free as possible from human intrusion.

Recent studies have shown that mixtures of air pollutants may cause more harm to plants than they would singly. Tingey and Reinert (Ref. 34) reported that sulphur dioxide (SO_2) and ozone (O_3) acted synergistically to injure alfalfa plants, even though the concentration of each pollutant in the mixture was below the threshold level for plant injury if the alfalfa plants were exposed to that pollutant alone. Such findings indicate that careful monitoring of the ecosystem to determine the effects of many pollutants is necessary when considering any large-scale construction activity. Changes in the quality of air can have deleterious consequences which may affect man and the production of food.

One of the most significant impacts to the site and adjacent areas will be caused by increased numbers of people associated with construction and operation of the facility. The work force required to build and operate the DCNEC will either commute from metropolitan areas or will move to small towns near the site. Many of these people will use their leisure

hours for outdoor recreation--dunebuggying, motorcycle riding, and other activities. These uses can have short- and long-term deleterious effects on the desert environment. Care will need to be taken to assure that lands adjacent to the site are protected from destructive use.

Hunting pressure on local game species can also be expected to increase. Since game populations are a relatively stable component of the habitat from year to year, there would only be enough animals to provide sport for a limited number of hunters. Steps would need to be taken to assure that over-harvesting did not occur.

Care in the selection of the construction site will help reduce the impact to any endangered species and critical plant communities, should they be present in the vicinity.

5.8.2.2 Effects of Operation

Infrequent increases in horizontal wind speed of several miles per hour would likely have little effect on desert biotic communities. A continuous increase could disrupt certain habitats, however, particularly where soil texture is conducive to erosion and soil movement. The magnitude, frequency and areal extent of potential wind speed increases has not been determined.

Dry-cooled nuclear energy centers may spawn convective storms which could modify local precipitation. Increases in rainfall, in a region which normally has less than 10 inches per year, could cause dramatic changes in plant community structure and species composition. Plants adapted to a more mesic condition would increase. Animal species would also change in relative abundance at first and perhaps species additions and

displacement would result in the long run. An increase in precipitation might also cause salts to accumulate in the soil in places with impeded internal drainage, with the result that only salt tolerant plants (halophytes) would grow. Animal species would change as a result of vegetational change. Increased precipitation would also alter the rate of erosion and weathering of soil parent material, with subsequent changes in physical and chemical properties of the soil.

Roads and railroads may interfere with movements of ground-dwelling animals while power lines, supporting structures, and cooling towers could interfere with avian travel. During migration, birds are particularly prone to strike high objects. The Washington Monument, Bartholdi Statue of Liberty, and radio and TV towers have all taken their toll. Apparently, most mortality during migration is related to the types and locations of lights on these structures. Fixed white lights seem to lure birds as moths are drawn to a flame, while flashing lights and red lights frighten birds away. (Ref. 30) In the lighting of tall structures at the DCNEC or along transmission corridors, these points should be considered.

In the past, transmission towers have caused mortality to large-sized birds of prey--particularly eagles. The transmission lines and supporting structures can be modified so that this problem can be substantially reduced. (Ref. 31)

It has been suggested that prolonged and repeated exposure of plants to low concentrations of ozone (O_3) can impair growth and affect plant community vigor and stability. Treshow and Stewart (Ref. 32) examined plants in natural communities and found that species varied greatly in their sensitivity to ozone. Cheatgrass (Bromus tectorum), Gambel's oak (Quercus gambelii), and trembling aspen (Populus tremuloides) were

injured by a single 2-hour exposure of 1500 ppm ozone. Fern (Ref. 33) found that high voltage transmission lines (up to 765 kV) do not generate measurable ozone above ambient ground level conditions adjacent to the lines under any weather condition. Since 500 kV AC lines are proposed for the DCNEC site, we would expect no problem. If double circuit 500 kV lines or 1100-1200 kV AC and 600-1200 kV DC lines are used, then biotic communities may have to be examined for any adverse effects due to ozone generation.

5.9 SOCIOECONOMIC IMPACTS

5.9.1 Population Size and Distribution

The DCNEC surrogate site is located in both Lincoln and Clark Counties in Nevada. The total population of Clark County in 1973 was estimated to be 307,537 and the population per square mile was 39.06. In contrast, the total population of Lincoln County was 2,303 and the population per square mile was 0.22. The largest town in Lincoln County is Caliente; the population was 831 in 1973, down from 916 in 1970. In contrast, Clark County has metropolitan Las Vegas, the largest city in Nevada, with a population of 144,333. (Ref. 35)

During the 1960s Nevada was the fastest growing state in the country, averaging 7.1% annual population increase. Seventy-two percent of the state's growth occurred in Clark County, resulting in an 11.5% average population growth rate for the county. There have been two primary reasons for this large population increase: the growth of military and nuclear research, which resulted in heavy industrial activity, and the expansion of the entertainment and tourism industry as a result of highly profitable gaming. (Ref. 36)

The population growth for Lincoln County averaged 0.5% during the 1960s, substantially lower than that for the rest of the state. Some of the small communities in Lincoln County that were based on mining activities which have become unprofitable or mechanized lost population. This depopulation trend was further enhanced by mechanization of agriculture and the merging of farms and ranches. The estimated growth rates for the early 1970s indicate less rapid growth trends,

with 4.3% for the state and for Clark County and -0.6% for Lincoln County. (Ref. 36)

The communities surrounding the surrogate site in both Clark and Lincoln Counties are small rural towns such as Carp, Elgin, Caliente, Moapa, and Glendale. The combined population of these communities is 941. Thus, even if only a small fraction of the DCNEC workers located in these communities, major socio-economic impacts would result.

5.9.2 Labor Force

The 1970 Clark County labor force totaled 121,353 while the Lincoln County work force was only 931. The services sector was the largest employer in Clark County, employing 30% of the work force, while government was the largest employer in Lincoln County, at 39.9%. The next largest group for both counties was white collar professionals, with 25.5% in Lincoln and 23.1% in Clark County. Craftsmen and foremen were the third highest skill group for Lincoln County (16.6%), while clerical and sales personnel were the third largest employment class for Clark County (22.7%). (Ref. 37)

A typical construction work force for a nuclear plant consists of various craftsmen, including pipefitters, laborers, electricians, iron workers, carpenters, operating engineers, boiler-makers, millwrights, painters, teamsters, and others. A utility usually lets contracts for its construction projects and the contractor (or contractors) negotiates with the unions. Generally, each of the various crafts is represented by its own union and has its own individual labor agreements. Major provisions of the labor agreements cover wages, working conditions, insurance, and fringe benefits. Over 95% of the construction work force in Clark County belong to a union. (Ref. 38)

As noted in Section 4.9.1, the DCNEC construction work force is expected to peak at 4600. By comparison, the unemployed construction labor force in Clark County for mid-September 1975 was 1150 persons (workers receiving unemployment compensation whose last job was in construction). (Ref. 38) Typically, construction workers will readily relocate to secure jobs. It is expected that minimal transfers of workers among job types would occur (i.e., few secretaries would become construction workers). Therefore, most of the workers would be expected to migrate into the area.

Most of the new workers would probably be people who are unemployed at the time job openings occur, with the skills required in the jobs, and with fairly short migration or commuting distances to the surrogate site area. A brief look at the current situation in the states closest to the site (i.e., Nevada, California, Arizona, and Utah) reveals the following: unemployed construction workers totaled about 1700 in Nevada in October, 13,700 in Arizona in August, and 3300 in Utah in June 1975. (Ref. 39) California represents the largest construction labor pool in the region but data on the number of unemployed construction workers there were not readily available. Since construction employment is very seasonal, these figures cannot be summed for a meaningful total of unemployed construction workers in the DCNEC region. Nevertheless, it appears that there is currently enough labor in the region, although not in the immediate site area, to construct a DCNEC.

Over half of the operating staff for the DCNEC would also be expected to migrate into the area. This includes management and technical personnel such as engineers, health physicists, controlroom operators, and superintendents. It is more difficult to determine the origins of secondary service workers, but most of them would probably migrate into the area also.

5.9.3 Income

Total personal income in 1973 was \$1,723 million in Clark County and \$9 million in Lincoln County. (Ref. 40) The median family income in 1969 for Clark County was \$10,805 and \$8,855 for Lincoln County, compared to the national average of \$9,586. The per capita income for the nation was \$3,119. This compares with \$3,538 for Clark County and \$2,556 for Lincoln County. Income distributions for Clark and Lincoln Counties for 1970 are shown in Table 5.14.

TABLE 5.14
DISTRIBUTION OF FAMILY INCOME IN
CLARK AND LINCOLN COUNTIES

<u>Family Income</u>	<u>Percentage of Families</u>	
	<u>Clark</u>	<u>Lincoln</u>
less than \$3,000	6.8%	13.9%
\$ 3,000 - 4,999	7.6	10.5
5,000 - 6,999	10.9	11.8
7,000 - 9,999	19.0	25.3
10,000 - 14,999	29.5	23.6
15,000 - 24,999	21.2	12.4
25,000 or more	5.0	2.5

Source: Ref. 40

5.9.4 Private Business

There were 1885 retail sales establishments in Clark County and 40 in Lincoln County in 1967. Clark County had 130 manufacturers while Lincoln County had only 2. The percentage of land being farmed is very low in both counties: 1.9% and

0.6% in Clark and Lincoln Counties, respectively, compared to 15.2% for Nevada as a whole and the national average of 47%. The 1969 average value per acre of this agricultural land including the buildings on it was \$247 for Clark County and \$222 for Lincoln County, compared to \$53 for Nevada and \$194 for the U.S. average. (Ref. 37)

5.9.5 Community Services and Facilities

5.9.5.1 Housing

Clark County had a total of 91,534 year-round housing units in 1970, 43% of which were rental units. Of the rental units, the average vacancy rate was 6.4%; of units for sale, 2.5% were vacant. The total number of vacant units in Clark County was 3,806 plus 1,281 seasonal units. In Lincoln County there were 880 year-round housing units, 35% of which were rental units. The average rental vacancy rate among these was 23.7% and of the sales units, 2.6%. The total number of vacant units in Lincoln County was thus 88%, plus 163 seasonal units. For both counties, the average number of rooms per housing unit was 4.6. (Ref. 37)

The median value of occupied units in 1970 was \$23,142 in Clark County and \$10,243 in Lincoln County. Similarly, the median gross rent was \$151 per month in Clark County and \$98 per month in Lincoln County. Of these units, 0.8% in Clark County and 4.7% in Lincoln County lacked some or all plumbing facilities. The owner-occupancy rate was higher in Lincoln County, which had an average of 70.3% owner-occupied homes, as compared to Clark County's 58% average. Almost 20% of the occupied housing units in Lincoln County were mobile homes; of the remainder only 27% were constructed since 1950. Many Lincoln County housing units are in poor condition because they are old and have not been well maintained. (Ref. 41) In contrast, 87% of Clark County housing has been constructed since 1950. (Ref. 36)

5.9.5.2 Medical Services

Medical Services for Clark County include 306 physicians and 9 hospitals with a total of 1,244 beds. (Ref. 36) Lincoln County health facilities consist of a 10-bed hospital in Caliente and one physician. (Ref. 41)

5.9.5.3 Police Protection

Police protection for Lincoln County includes the sheriff's department, some assistance from the State Highway Patrol, and a municipal police force in Caliente. (Ref. 41)

The Las Vegas metropolitan police department also serves parts of Clark County. North Las Vegas, Henderson, and Boulder City have their own municipal police. The Nevada State Highway Patrol also provides police assistance in Clark County. (Ref. 36)

5.9.5.4 Fire Protection

Fire protection for Lincoln County consists of 5 volunteer fire stations equipped with 7 trucks and 1 ambulance. (Ref. 41) Clark County has 13 fire stations equipped with 25 pumpers, 3 ladder units, 5 rescue units, 4 squad units, 4 tankers, and 2 ambulances. (Ref. 36)

5.9.5.5 Education

Education is the primary expenditure for both county governments. Lincoln County has 4 elementary schools, 2 high schools, and a Nevada State Training School for girls. Present capacity for the elementary schools is about 615 and about 300 for the two high schools. (Ref. 41) In 1970 a total of 832 persons were enrolled in Lincoln County schools. (Ref. 37) Clark County schools have the capacity to accommodate 77,000 students. In 1970 68,661 persons were enrolled.

Currently the Clark County school system is at full capacity; however, a district budget of \$26 million has been appropriated for school construction over the next 3 years. (Ref. 35) Local government expenditures for education in 1970 were 57.6% of the total expenditures for Lincoln County and 40.2% for Clark County.

5.9.5.6 Other Government Services

The county seats are located in Las Vegas (Clark) and Pioche (Lincoln), which are fairly equidistant from the surrogate site area. The Regional Planning Commission located in Las Vegas serves Clark County. There is no regional planning commission for Lincoln County. However, planners in St. George, Utah, have published several economic studies for Lincoln County.

5.9.6 Government Revenues

In 1967 government revenues totaled \$88.2 million in Clark County and \$1.2 million in Lincoln County. (Ref. 37) Depending on the location and ownership of the DCNEC, the local government's tax base could increase substantially. If the DCNEC is privately owned, property taxes would generate tax revenues primarily to the county in which the DCNEC is located.

The Nevada constitution sets a maximum tax rate of \$5.00 per \$100 of assessed value. (Ref. 42) While assessments are normally done by local assessors, the value of utilities' property is determined by the Nevada Tax Commission. (Ref. 42) The Tax Commission uses a mix of the following three methods for determining the value of utility property: 1) depreciated cost, 2) capitalized income, and 3) market value of outstanding stock and debt. (Ref. 43) The best present estimate of valuation for property tax purposes for a Nevada DCNEC is construction costs: \$7.2 billion for the completed center in 1975 dollars. (See Section 4.9.7.)

Currently in all areas of Clark County the nominal tax rate is the full allowable property tax rate of 5%. However, the effective tax rate in Clark County outside Las Vegas is about 1.25% of total value because the ratio of assessed value to sales price for property sold in the county is about 23%. (Ref. 44) This difference of about 10% between the actual and statutory assessed value/actual value ratios is probably due to changes in property values between time of assessment and time of sale, although it may be that there are informal policies to assess at less than 35% of value. Using the nominal tax rate of 1.25% and the estimated construction cost (\$7.2 billion in 1975 dollars) for a 12 reactor DCNEC, the annual property taxes for a DCNEC in Clark County would be \$90 million in 1975 dollars.

Lincoln County's property tax rates range from \$3.50 per \$100 of assessed value in unincorporated areas to \$5.00 in towns, with intermediate rates for fire districts. (Ref. 45) Assuming a total value of \$12 billion, the legal assessment ratio of 35% and the \$3.50 rate, the annual property taxes for a DCNEC in Lincoln County would be \$147 million. While the tax payments would be about the same in both counties, they would represent a much more significant addition to Lincoln County revenues than to Clark County revenues; the location of the DCNEC is very important to local tax revenues and hence to the local communities' ability to minimize socioeconomic impacts.

Under present Nevada law a state or federally-owned DCNEC would be exempt from any of the state taxes. However, federal facilities often make some payments to local governments in lieu of property taxes. These payments are not likely to exceed property taxes on an equivalent private facility.

In addition to the property tax there is a state tax of 2% on net profits of utilities and state unemployment insurance taxes which range from 0.6% to 3% of the first \$6,100 paid to each employee per year. (Refs. 46,47)

5.9.7 County Land Use Breakdown

Private land in Clark County totals 472,394 acres and represents 10% of the county land area. Of the 90% of Clark County land which is publicly owned, the Bureau of Land Management controls the largest portion with 64.2%; U.S. Fish and Wildlife Service is next with 20.6%; and the National Forest lands are 12.2% of the public lands. While it is expected that most Clark County land ownership and control patterns are likely to continue in the future, the U.S. Fish and Wildlife Service has proposed to expand the eastern boundary of the National Wildlife Range by about 5,800 acres. (Ref. 36)

Public lands represent over 99% of the 6,816,000 acres of Lincoln County. The Bureau of Land Management regulates the use of 83.5% of these public lands. Other major public land use includes 13.7% for a Gunnery Range and Game preserve, 0.4% of national forest, and about 0.1% of State Parks and Recreation sites. Privately owned land occupies only 67,903 acres of Lincoln County. Over 50% of this land is used for agricultural purposes. (Ref. 41)

5.9.8 Socioeconomic Impacts of a DCNEC at the Surrogate Site

The significant differences between the socioeconomic impacts of a DCNEC at the surrogate site and these impacts if the DCNEC were located elsewhere in the arid west result from the proximity of the site to Las Vegas. In most areas of the arid west the site would be significantly removed from existing population centers. This would mean that nearly all of the

workers and their families would have to migrate to the site area. New housing, private service industries, and public service facilities would be expected near the site, at least on a temporary basis, during construction. Even after construction, a new or significantly expanded town would remain near the site.

The closer a major construction site is to an existing city of some size, such as Las Vegas, the more likely it is that people would commute to the site from this city, rather than locate nearer to the site itself. For example, during construction projects at the nuclear test site near Mercury, Nevada, in the 1960s the peak work force was 10,000 (operating and construction workers). A relatively high percentage of workers commuted approximately 70 miles from the Las Vegas area to the site. The highway system leading to the site was in good condition and bus service was subsidized for the permanent employees. The temporary construction workers received a travel allowance. Housing, private service industries such as retail stores, and public service facilities such as schools, water, and police were not available near the test site. Because these facilities were more readily available in and near Las Vegas and because transportation services were good, Las Vegas grew while small towns closer to the site, like Indian Springs, were less affected. (Ref. 48)

The experience at Boulder Dam (now Hoover Dam) provides another example. Hoover Dam is located approximately 30 miles from Las Vegas. Construction was begun in 1931; the peak employment reached 5,217 workers in 1934. In 1931, the government and contractors began developing housing for the workers only 5 miles from the dam. Even though the dam site was closer to Las Vegas than either the nuclear test site or the DCNEC surrogate site, there was minimal commuting to and from

Las Vegas. (Ref. 49) Of course, roads to the dam site from Las Vegas were not as good in the early 1930s as those to the test site were in the 1960s and a smaller fraction of the population owned automobiles 40 years ago.

Thus, the availability of housing, public and private service facilities, and transportation makes a dramatic difference in the living locations of construction and operating workers. These differences also influence the size of the income and employment multiplier, due to differences (noted in Section 4.9.2) in the size of the multiplier in rural and urban locations.

Since the population of Lincoln County is small, the number of local residents employed at the DCNEC in either construction or operation would be negligible; hence there would be negligible local benefits from reduced unemployment.

Limited site-specific research indicates that the lack of transportation facilities in Lincoln County, combined with the lack of housing and other public and private services, would influence the location decisions of incoming residents. The farther the site is from Las Vegas, the more people would live in nearby small towns in Clark County. It seems unlikely that significant numbers of people would locate in Lincoln County unless better housing and other public and private services are planned and built ahead of construction; this would significantly increase the cost of the DCNEC. Unless such services are provided, most workers would probably locate in Clark County. If this is so, a site in northern Clark County would generate fewer negative socioeconomic impacts than a site nearer to Galt in Lincoln County because most tax revenues would accrue (via DCNEC property taxes) to the county where the site is located.

As noted in Section 5.9.6, the county in which the DCNEC would be located is expected to receive about \$150 million annually in property taxes. This \$150 million would be significant in Clark County, which had \$88 million in revenues in 1967, and overwhelming in Lincoln County, which had only about \$1 million.

Employment, population, and income projections are available for Bureau of Economic Analysis Area 161 (BEA-161) which covers nine counties (four in southeastern Nevada and five in northwestern Utah), including Clark and Lincoln Counties. Data are given separately for Clark County, but only totals are available for the remaining eight counties. (Ref. 50)

Adding a total peak construction, operating, and secondary work force of over 10,000 would cause a significant impact in Lincoln County, which had 1,000 workers in 1970; the impact would not be as significant in Clark County, which had over 120,000 workers. Even the ultimate work force of less than 1,500 operating and secondary service workers would be much larger than the current total Lincoln County employment. Without a DCNEC employment in Clark County is expected to grow to over 185,000 by 1990, as compared to less than 23,000 for the rest of BEA-161, including Lincoln County. (Ref. 50)

Other population impacts would follow this pattern. Population would stabilize at over 3,000 in the site area, compared to less than 1,000 now, but even the peak population of 23,000 would not be large compared to the nearly 150,000 in Las Vegas and over 300,000 in Clark County. Without a DCNEC, the Clark County population is expected to be over 500,000 by 1990, and the population of the rest of BEA-161, which includes Lincoln County, is expected to be less than 60,000. (Ref. 50)

Personal incomes generated by the DCNEC would peak at over \$132 million and stabilize at over \$17 million, compared to 1973 totals of \$1,700 million in Clark County and \$9 million in Lincoln County. Without the DCNEC, total personal incomes are expected to grow to over \$2.7 billion by 1990 in Clark County, and to about \$260 million in the other eight counties in BEA-161, including Lincoln County. (Ref. 50)

The peak projected housing use of over 9,000 units can be compared with over 3,800 vacant year-round units and nearly 1,300 seasonal units in Clark County. Even the ultimate housing demand caused by the DCNEC of about 1,300 units could not be supplied in Lincoln County without significant new construction, since there were less than 100 year-round units vacant there in 1970.

5.10 OTHER ENVIRONMENTAL CONSIDERATIONS

5.10.1 Aesthetics

Currently, there is no large-scale development within the Galt site. The rail line, a few dirt roads, some fences, a handful of dwellings, and irrigated pastures dotted along the Wash are the only clues to human existence in the area. This total accounts for very little visual impact from human activities in this region. Within this natural setting, the cooling towers and power plants of a DCNEC would rise in obvious contrast and alter the character of the landscape. Certainly, the visual impact of a DCNEC is far greater against this backdrop than if it were set amidst other industrial activities.

Since very few people live in and around the surrogate site, it might be concluded that opposition to the visual impact of a DCNEC might be negligible simply from lack of exposure. This is not the case, however, as most of the site is visible from Interstate Highway 15, the main link between Salt Lake City and Las Vegas. Therefore, the sight of a DCNEC in the Galt region would confront thousands of people daily. It must be concluded then, that the visual impact of a Galt DCNEC would be great due to its contrasting character and degree of exposure. Considerable visual impact would result from the long and wide transmission corridors required from the remote DCNEC site to the major load centers.

Yet relating visual impact to aesthetics is difficult, as people will react to this change in the character of the landscape from individual perspectives. Some would resent this encroachment upon the natural beauty of an untouched

desert. Some would welcome the sight of man's high technical achievements enhancing the desert wasteland. Others would have no opinion at all.

So although the visual impact would be great, the effect on the viewer's aesthetic senses could vary from awe to apathy to anger. Quantification of the aesthetic effect of a DCNEC at the Galt site would necessitate either interviewing a cross section of people to predict their reaction to the hypothetical situation or polling reactions to an analogous situation existing elsewhere.

5.10.2 Noise

Environmental impact studies of existing nuclear power plants using cooling towers have concluded that the resulting noise pollution is insignificant. The level of noise at the plant site boundary is roughly equal to that generated by a small household fan. A dry-cooled nuclear plant would generate somewhat more noise, as the volume of air flowing through a dry tower is several times greater than in a wet tower flow. Putting twelve of these in an area of several square miles could result in an increased noise level, but certainly one that is far from disturbing. The lack of inhabitants in the area surrounding the Galt site minimizes this problem.

Construction noise, which would be considerable at times, would not be heard at nearby populated areas or public highways due to their distance from potential reactor sites.

REFERENCES

SECTION 5

1. Nevada Revised Statutes (NRS), Chapter 703-704.
2. Nevada Revised Statutes (NRS), Chapter 704.330.
3. Nevada Revised Statutes (NRS), Chapter 704.820-704.900.
4. Nevada Revised Statutes (NRS), Chapter 704.892.
5. J. H. Stewart and J. E. Carlson. Preliminary Geologic Map of Nevada. USGS, in cooperation with Nevada Bureau of Mines and Geology, Misc. Field Studies, Map MF-609, 1974.
6. C. M. Tschanz and E. H. Pampeyan. Geology and Mineral Deposits of Lincoln County, Nevada. Nevada Bureau of Mines, Bulletin 73, 1970.
7. T. E. Eakin. "Ground-Water Appraisal of Coyote Spring and Kane Spring Valleys and Muddy River Springs Area, Lincoln and Clark Counties, Nevada." USGS, Ground-Water Resources-Reconnaissance Series, Report 25, 1964.
8. M. D. Mifflin. "Delineation of Ground-Water Flow Systems in Nevada." Technical Report Series H-W, Publication No. 4, Desert Research Institute, University of Nevada System, Reno, 1968.
9. W. W. Hays, Assistant Branch Chief, USGS, Denver. Written communication to S. J. Shupe, Battelle-Northwest, Richland, WA, dated October 14, 1975.
10. E. Rush. "Groundwater Appraisal of the Meadow Valley A Area." Groundwater Resources - Reconnaissance Series, Report 27, State of Nevada Department of Conservation and Natural Resources, Carson City, 1964.
11. T. E. Eakin, et al. "Contributions to the Hydrology of Eastern Nevada." Water Resources Bulletin 12, Nevada State Engineer, 1951.
12. G. Hardman. "Nevada Precipitation and Acreages of Land by Rainfall Zones." Report of the Nevada University Agr. Exp. Sta., 1936.

13. C. Y. Bourns. "Feasibility of Exchange of Waters from the Muddy River and Wells of the Nevada Power Company at Glendale, Nevada." Report Series No. 5, University of Nevada, 1963.
14. Local Climatological Data Annual Summary with Comparative Data. U.S. Department of Commerce, NOAA Environmental Data Service, Las Vegas, Nevada, 1971.
15. Groundwater Resources Reconnaissance Series, Report 25, Dept. of Conservation & Natural Resources, Nevada.
16. R. F. Quiring. "Climatological Data, Nevada Test Site and Nuclear Rocket Development Station." ESSA Research Laboratories Technical Memorandum - ARL 7, August 1968.
17. J. C. Beatley. "Biomass of Desert Winter Annual Plant Populations in Southern Nevada." Oikos 20:261-273, 1969.
18. W. H. Rickard and J. C. Beatley. "Canopy-Coverage of the Desert Shrub Vegetation Mosaic of the Nevada Test Site." Ecology 46:524-529, 1965.
19. W. H. Rickard and L. M. Shields. "An Early Stage in the Plant Recolonization of a Nuclear Target Area." Radiat. Bot. 3:41-44, 1963.
20. G. Tsukamoto. Big Game Investigations and Hunting Season Recommendations. Nevada Dept. of Fish and Game, Reno, NV, 1974.
21. W. A. Molini and L. Barngrover. Upland Game, Migratory Game Birds, Fur Investigations, and Hunting Season Recommendations. Nevada Department of Fish and Game, Reno, NV, 1974.
22. United States Department of Interior. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Refuge Leaflet 1351500-8, February 1974.
23. W. G. Bradley and R. A. Mauer. "Rodents of a Creosote Bush Community in Southern Nevada." The Southwest Naturalist 17(4):333-344, 1973.
24. J. M. Linsdale. "A List of the Birds of Nevada." The Condor 53:228-249, 1951.
25. G. W. Gullion and G. C. Christensen. "A Review of the Distribution of Gallinaceous Game Birds in Nevada." The Condor 59:128-138, 1957.

26. N. K. Johnson. "The Distribution of Boreal Avifaunas in Southeastern Nevada." Biological Society of Nevada Occasional Papers, No. 36, 1973.
27. United States Department of Interior. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Refuge Leaflet 231, July 1968.
28. United States Department of Interior. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Refuge Leaflet 132-R4, December 1970.
29. G. A. Wunz. "Tolerances of Wild Turkeys to Human Disturbance and Limited Range." Northeast Fish and Wildlife Conference, May 23-26, 1971, Portland, ME, 1971.
30. W. W. Cooke. "Bird Migration." U.S. Dept. of Agric. Bull. No. 185. Washington, DC, 1915.
31. M. Nelson. "Power Lines and Birds of Prey." Presented at the Northwest Electric Light and Power Association, Engineering and Operating Conference, Yakima, Washington, April 22, 1974.
32. M. Treshow and D. Steward. "Ozone Sensitivity of Plants in Natural Communities." Biol. Conserv. 5(3):209-214, 1973.
33. W. J. Fern. Field Investigation of Ozone Adjacent to High Voltage Transmission Lines. Paper presented at the IEEE PES Winter Meeting, New York, NY, 1973.
34. D. T. Tingey and R. A. Reinert. The Effect of Ozone and Sulphur Dioxide Singly and in Combination on Plant Growth." Environ. Pollut. 9:117-125, 1975.
35. Population Estimates and Projections. U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census, Series P-25, No. 573, May 1975.
36. EDAW Inc. (E. K. Bow, Dean, Austin, Williams). "Sea Farer Site Survey," 50 Green Street, San Francisco, CA, December 1975.
37. County and City Data Book, 1972. U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census, U.S. Government Printing Office, Washington, DC, 1973.

38. Telephone conversation with Ms. Rocitor, Economist at the Nevada State Employment Office.
39. Telephone conversation with Mr. Mike Crowley, Arizona Employment Data and Research Department, December 2, 1975.
40. "County and Metropolitan Area Personal Income." In Survey of Current Business, U.S. Department of Commerce, Bureau of Economic Analysis, U.S. Government Printing Office, April 1975.
41. J. C. Willie and Associates. "Analysis Studies," prepared for Lincoln County Commissioners, Pioche, Nevada, October 1974.
42. Section 2, Article X, Nevada Constitution.
43. Telephone Interview with Nevada Tax Commission Staff, December 2, 1975.
44. 1972 Census of Governments, Vol. 2; Taxable Property Value and Assessment--Sales Price Ratios. Part 2: Assessment--Sales Price Ratios and Tax Rates.
45. Telephone Interview with Lincoln County Tax Assessor's Office, November 21, 1975.
46. Sections 406.060, 709.100, and 709.110, Nevada Revised Statutes.
47. State Tax Guide, Commerce Clearing House, 1975, pp. 556-7.
48. Telephone Conversation with David Miller (ERDA) at the Nevada Test Site, September 10, 1975.
49. Telephone Conversation with William J. Williams, U.S. Department of the Interior, Boudler City, NV, September 10, 1975
50. Area Economic Projections, 1990. U.S. Department of Commerce, Bureau of Economic Analysis, U.S. Department Government Printing Office, 1974.
51. Nevada Revised Statutes (NRS), Chapter 704.040.
52. Nevada Revised Statutes (NRS), Chapter 704.210.
53. Nevada Revised Statutes (NRS), Chapter 459.
54. Nevada Revised Statutes (NRS), Chapter 459.020.

APPENDIX A

A.1 LOAD GROWTH PROJECTIONS

Attempting to predict energy consumption a decade from now and beyond is a difficult task. Depending upon assumptions and opinions, different studies will arrive at different conclusions. Discussed below are three studies undertaken to predict electricity demand in the western region and how these forecasts relate to the DCNEC concept. Significantly, even the most conservative of these projections confirms that ample demand will exist in the study area for the output of at least one 12-reactor DCNEC (14.4 GWe) in the 1985-2000 period.

A.1.1 Extrapolation Forecast

In a report (Ref. 1) recently completed by Battelle-Northwest (BNW), historical trends in peak demand and electrical energy usage were analyzed for all power supply areas (PSAs) and National Electrical Reliability Council (NERC) areas in the U.S. (See Figures A-1 and A-2 for their geographic boundaries).

Growth rates were found to be quite constant over the 1956-71 period for all of these areas. The growth rates averaged 7.1% for WSCC and ranged from 4.1% in PSA 42 (N.E. Washington and N. Idaho) to 8.8% in PSA 31 (Wyoming). If these trend rates are assumed to continue into the distant future and if a uniform 60% annual load factor (ALF) is assumed, the expected additional capacity coming on-line between 1985 and 2000 would be as shown in Table A-1 for each PSA in WSCC. Using an average

FPC POWER SUPPLY AREAS (PSA's) IN THE UNITED STATES

Figure A-1. FPC Power Supply Areas (PSAs) in the United States

Figure A-2. Regional Electric Reliability Councils in the United States

TABLE A.1
 EXPECTED 1985-2000 CAPACITY ADDITIONS
 ASSUMING 1956-1971 TREND CONTINUATION

PSA	1985 - 2000 Capacity Additions (GWe)
30	5.0
31	7.0
32	16.4
39	8.7
41*	12.9
42	3.8
43	36.7
44 & 45	25.6
46*	55.3
47*	99.6
48*	28.1
<hr/>	
WSCC Area	299.1
* DCNEC Area	195.9

figure of 50% nuclear capacity in WSCC and calculating by the BNW linear programming model of the U.S. electric power industry (Ref. 2) gives a 1985-2000 additional nuclear capacity in WSCC of nearly 150 GWe. Most of this nuclear capacity would probably be in states bordering on the Pacific, while fossil-fueled power plants would be more important in the Rocky Mountain States. If all of this nuclear capacity were concentrated in DCNECs of the 12 reactor size, about 10 such centers would be needed.

A.1.2 Utility Forecast

Estimates of generating capacity additions in 1985-2000 based on current load growth estimates of the utilities in the surrogate site region are given in Table A-2. A substantial portion of these additions, in terms of capacity, may be nuclear plants. In utility advance plans for central and northern California, 88% of the new capacity planned for 1985 to 2000 is expected to be nuclear. Southern California has placed increasing dependence on coal-fired plants in Arizona, Utah, and New Mexico for new capacity in the 1975-1985 period. Sixty percent of the 1985-2000 capacity additions expected by the utilities in the DCNEC area would amount to 46 GWe nuclear capacity.

TABLE A.2
CURRENT ELECTRIC UTILITY ESTIMATES OF
NEW CAPACITY, INCLUDING RESERVES

PSA	Capacity Additions (GWe)	
	<u>1985-1995</u>	<u>1985-2000</u>
41	5	6
46	25	32
47	22	28
48	<u>8</u>	<u>10</u>
DCNEC Area	60	76

A.1.3 Tyrrell Forecast

Tyrrell (Ref. 3) has made forecasts of electricity use by state based on an econometric model of electricity demand. (Ref. 2) This forecast implies a 3.9% average growth rate in electricity use in WSCC from 1970-2000 and a range from 2.6% in Idaho and Montana to 5.3% in Nevada. From these forecasts and a 60% ALF, new capacity in the 1985-2000 period in the western states would be 53 GWe (Table A-3). At half of this total new capacity, the nuclear additions would amount to 27 GWe. The capacity additions in the DCNEC surrogate site service area (California, Nevada, Arizona, and Utah) would be 33 GWe; at 60% of these capacity additions, the nuclear additions would be 20 GWe.

TABLE A.3
 EXPECTED 1985-2000 CAPACITY ADDITIONS
 ACCORDING TO TYRRELL'S FORECASTS

<u>State</u>	<u>1985-2000 Capacity Additions (GWe)</u>
California*	26.9
Oregon	4.8
Washington	9.9
Idaho	1.0
Montana	0.7
Wyoming	0.3
Nevada*	2.2
Utah*	1.3
New Mexico	0.9
Colorado	2.8
Arizona*	2.4
WSCC Area	53.2
* DCNEC Area	32.8

REFERENCES

APPENDIX A

1. L. E. Erickson, Regional Analysis of the U.S. Electric Power Industry, Volume 3, Regional Demand Analysis and Consumption Forecasts, BNWL-B-415 V3, Battelle-Northwest, Richland, WA, June 1975.
2. W. A. Reardon, et al., Regional Analysis of the U.S. Electric Power Industry, Volume 1, Summary and Results, BNWL-B-415 V1, Battelle-Northwest, Richland, WA, July 1975.
3. T. J. Tyrrell, Projections of Electricity Demand, ORNL-NSF-EP-50, Oak Ridge National Laboratory, Oak Ridge, TN, November 1973.

APPENDIX A.2: COMPARISON OF TRANSMISSION ASPECTS OF DISPERSED SITING

The dispersed siting power plant pattern that is being established for the intermediate range 1976-85 capacity additions is generally as follows:

Southern California

- Additions at San Onofre
- Coal-fired plants in southern Nevada and Utah and at the Four Corners at distances up to 600 miles
- Nuclear plants in the lower San Joaquin Valley

Central California (in which Southern California utilities may participate)

- Nuclear plant in the southern San Joaquin Valley

Arizona

- Coal-fired plants in southern Utah and at the Four Corners

A pattern for alternative dispersed sites for nuclear plants in the longer range 1985-2000 period has not been identified because 1) new cooling water supplies are increasingly scarce, 2) the policies of the recently-formed California Shorelines Commission on the use of coastal sites are still uncertain, and 3) it has not been decided whether to use dispersed dry-cooled nuclear plants or wet-cooled coal-fired plants at more distant locations in Utah and at the Four Corners. Selection patterns for plant types and sites after 1985 will depend on the results of current site studies and on political and economic developments.

Although a firm pattern for post-1985 dispersed nuclear plants is lacking, areas under consideration and those which will not be filled to capacity by 1985 are discussed briefly and shown in Figure A-3 in relation to the Galt site. Dispersed sites,

Figure A.3 Sites and Site Areas Under Investigation for Post-1985 Nuclear Plants in Southern California and Arizona, in Relation to Location of Load Centers

for purposes of this study, include both wet-cooled and dry-cooled plant sites but exclude fossil fuel-fired plant sites.

The location of possible dispersed plants with respect to the load centers (Figure A-3) is not the only factor to be considered in transmission requirements. Other important elements are reinforcement of the transmission system between dispersed sites to maintain system stability and the degree to which the transmission system would meet reliability standards in the event one of the dispersed plants were lost (i.e., whether a system would be able to transmit power from other sources to the loads normally served from the shut-down dispersed plant). Such considerations require a rigorous analysis of the dispersed system before a valid comparison can be made.

Certain conclusions regarding dispersed nuclear plants have been drawn from the information described above:

In Southern California

- Dry-cooled sites appear to be available in the Mojave Desert that are closer to the loads than the Galt site is.
- If shoreline sites could be approved, transmission construction and operating costs would be much less than for the Galt site.
- Other site possibilities appear to be as far from major loads as Galt, or farther.

In Arizona

- Suitable dry-cooled sites appear to be available fairly close to load centers.
- Wet-cooled sites are distant and in coal-bearing areas.

In the absence of a recognized scheme for putting dispersed nuclear plants into service in the 1985-2000 period, an arbitrary assumption could be made that sites for dry-cooled

or ocean-cooled plants could be found at an average distance of 100 miles from the 500 kV ring around the Los Angeles area or from terminal plants at other load centers. A comparison between the transmission system for a hypothetical case and the system for the Galt DCNEC is of interest.

For example, one could assume that two four-unit plants could serve the Los Angeles area, one one-unit plant the San Diego area, one two-unit plant the Phoenix area, and one one-unit plant could feed into the system near Las Vegas. The number of 500 kV AC circuits required for reliability purposes would be:

from each of the 4-unit stations - 3 high capacity
 from each of the 2 unit stations - 2 high capacity
 from each of the 1 unit stations - 2 standard capacity;
 445 miles total

At an average 100 miles each the totals would be:

	<u>No. of Circuits</u>	<u>Miles of Circuit</u>	<u>Type</u>
From two 4-unit stations	3 (dbl cir)	600	High Capacity
From one 2-unit station	2	200	High capacity
From two 1-unit stations	4	445	Standard Capacity

Transmission costs for this case can be compared with those for the Galt case (with the underground transmission link) as follows:

	Capital Cost \$ Million	Total Annual Costs \$ Million	Transmission Costs per Unit of Energy @75% Plant Factor Mills/kW-hr
Galt Case	1930	380	4.0
Hypothetical Dispersed Case	560	110	1.2
Difference	1370	270	2.8

A summary of findings of transmission economics for the Galt surrogate site follows:

	<u>Mill/kW</u>
• Unit cost of transmission if overhead lines could be routed from the Galt site southward, through the Henderson corridor or across the corner of the Desert Wildlife Range	3.1
• Added cost of:	
- 17 miles UG through Henderson corridor	0.9 4.0
- 100 mile overhead detour through the testing grounds	0.8 3.9
- Routing LA lines via Tonopah and others through UG link	1.4 4.5
• Unit cost of transmission for hypothetical dispersed plants 100 miles distant from bulk transmission terminal points near load centers	1.2

A.3 TRANSMISSION ASPECTS OF A 3-DCNEC CONFIGURATION SERVING CALIFORNIA LOAD CENTERS

Previous discussions of transmission aspects were confined to the Galt site and its power marketing area. Questions relating to the strengthening of the western loop for maximizing economic transfer of power or for maintaining stability were not considered, and it was assumed that any transmission lines needed for these purposes would be needed whether the new generating capacity resulted from a DCNEC or dispersed plants.

The following system configurations are based on a broader view. The development of nuclear energy center may facilitate beneficial integration over a wide area. The scope of this study does not permit comparisons, but the two cases illustrate the manner in which an integrated supply to California loads may be approached, assuming that three such DCNECs were to materialize within the 1985-2000 time frame.

These configurations are combinations of three surrogate DCNEC sites out of a total of four (Oregon, Sacramento, lower Colorado and Galt) with arbitrary removal of the Galt site to a more distant location (Four Corners) to obtain an indication of the costs associated with added distances. In these cases the 3-DCNEC combinations would serve only California loads which will constitute most of the forecast load growth in the 1985-2000 period.

The qualifications and assumptions stated previously for the Nevada surrogate site apply to the following cases. Since many of the lines in these configurations are more than 450 miles in length, extensive use is made of DC transmission and the chosen voltage is +600 kV DC.

Transmission systems used for three configurations are shown in Figures A.4, A.5 and A.6.

The DC transmission and converter configurations selected almost certainly will be modified as this technology develops. As long-time DC thermal performance is improved and better understood, and with development of DC circuit breakers and improved controls, there is little doubt that the number of lines shown for DC overlay transmission could be reduced.

If such a DCNEC generation and transmission plan is implemented, there will be a number of interconnections between the overlay system and the utility transmissions. Such interconnections will strengthen the entire southwestern US electrical network. Substantial benefits in reliability and system stability will result. Moreover, some reduction from the number of AC transmission circuits needed in the overlay system may also be realized.

A.3.1 Cost Estimates - 3-DCNEC Configuration

A.3.1.1 Capital Investment

Included in the estimates of capital investment are transmission lines, switching terminals, rectification and inversion equipment for DC lines, and series compensation.

Estimated investment cost for the lines radiating from each group of DCNECs are shown below. Each transmission system serves three 15-GW DCNECs.

Figure A.4 3-DCNEC Complex-Configuration A

Figure A.5 3-DCNEC Complex-Configuration B

Figure A.6 3-DCNEC Complex-Configuration C

Estimate of Capital Investment - Transmission

<u>DCNEC Configuration</u>	<u>\$ Billion</u>
A - (with Sacramento DCNEC)	3.7
B - (with Nevada DCNEC - Galt)	4.7
C - (with Nevada DCNEC removed to Four Corners)	4.8

A.3.1.2 Losses

The value of losses is based on the same assumptions given for the single Galt DCNEC. Under these assumptions the value of annual losses in the transmission systems of the three DCNEC groups would be:

<u>DCNEC Group</u>	<u>Percent of Energy Input</u>	<u>Value of Losses \$ Million/Year</u>
A	3.3	175
B	3.7	210
C	4.5	245

An overall cost comparison of the three configurations, including fixed charges on investment, operating and maintenance costs and the value of annual transmission losses, follows:

<u>Configu- ration</u>	<u>Annual Fixed Charges \$ Million</u>	<u>Annual Losses \$ Million</u>	<u>Total \$ Million</u>	<u>Total Annual Cost \$ per kW of Installed Capacity</u>	<u>Unit Energy Cost at 75% Plant Factor Mills/kW-hr</u>
A	630	175	805	18.80	2.8
B	805	200	1005	23.40	3.6
C	815	245	1060	24.50	3.7

A comparison of the A and B cases indicates that the value of having an DCNEC in the general vicinity of Sacramento, rather than at an eastern Nevada site such as Galt, is \$1,000 million in capital investment (from capital investment table on preceding page) or \$200 million per year, including value of losses (from the above table).

A comparison of the B and C cases might be expected to convey useful information regarding the effect of the more distant location of the Galt Plant removed to Four Corners, but these data are obscured by the underground sections assumed to be necessary for the Henderson corridor. A separate calculation of the incremental costs of 400 miles of five ± 600 kV DC lines, without intermediate stations, is \$400 million in capital, or \$115 million per year including cost of transmission losses.

The comments made previously with respect to time relationships in making the investment and in loading of the system apply here also.

DISTRIBUTION

No. of
Copies

- 30 Nuclear Regulatory Commission
Office of Special Studies
Washington, D. C. 20555
- George Sege (25)
Acting Project Director
Nuclear Energy Center Site Survey
- M. L. Ernst
D. E. Sells
R. T. Jaske
M. L. Au
F. W. Young
- 2 Energy Research and Development Administration
Washington, D. C. 20545
- Theodore Beresovski
Chief, Advanced Concepts
- 1 Energy Research and Development Administration
Richland Operations Office
Federal Building
Richland, WA 99352
- Benjamin Melton
Chief, Research and Development Programs
Branch
- 1 Energy Research and Development Administration
Nevada Operations Office
P. O. Box 14100
Las Vegas, NV 89114
- M. E. Gates
Manager
- 2 Pacific Northwest River Basins Commission
1 Columbia River
Vancouver, WA 98660
- Donel J. Lane
Chairman
- Malcolm H. Karr

No. of
Copies

1	<u>Energy Resources Conservation and Development Commission</u> 455 Capitol Mall Sacramento, CA 95814 K. Elia Administrative Assistant
1	<u>Nevada Public Service Commission</u> Carson City, NV 89701 Noel A. Clark Chairman
1	<u>Electric Power Research Institute</u> 3412 Hillview Avenue Palo Alto, CA 94303 Laura Henning
1	<u>Washington Public Power Supply System</u> 3000 George Washington Way Richland, WA 99352 R. A. Chitwood Manager, Licensing and Environmental Programs
2	<u>Consultants</u> C. C. Diemond 4840 SW Fairhaven Lane Portland, OR 97221 Wm. J. Dowis 1603 Judson Richland, WA 99352
59	<u>Battelle-Northwest</u> A. Brandstetter (20) D. B. Cearlock M. G. Curry D. W. Dragnich J. G. Droppo

No. of
Copies

Battelle-Northwest

L. E. Erickson
R. E. Fitzner
H. Harty
B. M. Johnson (10)
W. W. Leity
K. A. McGinnis
J. V. Ramsdell
R. L. Richardson (9)
A. H. Schilling
S. J. Shupe
W. H. Swift
R. L. Watts
R. W. Wallace
R. D. Widrig
Technical Information (3)
Technical Publications